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SCIENCE AND TECHNOLOGY IN PUBLIC AFFAIRS

ALTHOUGH the seventh annual report of the National Science Foundation covers the year ended June 30, 1957 (see *Nature*, June 21, p. 1710), the expanded programmes for the Foundation announced by President Eisenhower in his message on education to Congress on January 27, 1958, gives especial interest to the report, apart altogether from the steps to improve and expand Anglo-American co-operation in research and development indicated by the President and Mr. Macmillan in their joint statement on their talks last October. In his budget message of January 13, President Eisenhower had proposed appropriations of 140 million dollars for the Foundation in 1959, compared with 40 million dollars in 1957 (apart from some 32 million dollars on account of the International Geophysical Year). Of this 40 million dollars, 664,561 dollars was allocated to national science policy studies, nearly 7,500,000 dollars to research grants in the biological and medical sciences, just over 7,500,000 dollars to research grants in the mathematical, physical and engineering sciences, and 289,100 dollars to the social sciences. Grants in support of research facilities totalled, in biological and medical sciences, 884,800 dollars, and in the mathematical, physical and engineering sciences, 4,496,899 dollars. Graduate fellowships received 3,353,605 dollars, education in the sciences 10,947,711 dollars, the President's Committee on Scientists and Engineers 117,517 dollars, the review of research and training 1,020,143 dollars, and the dissemination of scientific information 994,736 dollars, with 122,069 dollars for attendance at international scientific meetings.

It is expenditure of this order that is now to be increased to 58 million dollars on research grants and 82 million dollars (including 3 million dollars on administration) for the improvement and extension of education in science. The current annual report of the Foundation enables the British reader to judge more accurately the scale and character of the new efforts of the United States in this field, and to assess to some extent the new need for modifications and developments in our own effort, both to eliminate waste and inefficiency and to improve its balance and facilitate smooth co-operation with the United States. It is not so much the scale of the British effort in comparison with that of the United States that is in question as the character of the institutions by which it is operated, and the spirit and outlook in which they are administered; on this the present report of the National Science Foundation and the statement of its director, Dr. A. T. Waterman, in particular, throw a flood of light.

No one institution in Britain carries quite the responsibility and concern for scientific endeavour that the National Science Foundation bears in the United States. The closest approach is probably the office of the Lord President of the Council; but even so, responsibility is dispersed between him, the Advisory Council for Scientific Policy, the Defence Research Policy Committee, the University Grants Committee and various other bodies the concerns and efforts of which it could scarcely be said, as Dr. D. W. Bronk, chairman of the National Science Board, writes in this annual report, that they are "permeated by devotion to the belief that the furtherance of science enriches the intellectual and spiritual life of the people of our country, broadens and deepens the quality of our culture and ennobles our national ideals". Indeed, any consideration of incidents over the past few years suggests that the nearer we approach to ministerial level in Britain the less that is likely to be true. So far as the Government and its institutions are concerned, science is regarded as serving practical ends, rather than as a great adventure of the human mind.

That may be a primary reason why we lack an effective institution in Britain comparable to the National Science Foundation with its statutory responsibility "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences". Much turns on the place which science and the scientist hold in the public esteem. One lesson which should have been impressed upon both the Government and the public by the shortage of technologists and of scientists, and especially of teachers of science and mathematics, is the dependence of the attractiveness of a career to the school-leaver or graduate on the esteem its practitioners enjoy in the public mind.

In this context, Dr. Waterman's exposition of his understanding of a national policy for science and its implications is of profound interest. Taking as science the accumulated knowledge concerning the world we live in and how it operates, which is steadily increased by active research, based on observation and experiment, Dr. Waterman emphasizes, first, that such exploration depends on an individual's choice of where and how to explore, and that the importance and flexibility of his project or programme and the significance of his final results can only be properly appraised and evaluated by his scientific colleagues in the same field. From that follows the fundamental importance of free communications and a national policy for fundamental research, at least; though no government or other agency can rationally attempt to formulate programmes for individual scientists, still less prescribe the methods of attack. Those must be left to the individual scientist: a national policy in science, at least as distinct from technology, must be limited to discovering the objectives which scientists regard as important and seeing that the scientists are provided with adequate means for the attack.

This implies, as Dr. Waterman indicates, wholehearted support for competent basic research where needed; in particular, it implies provision of the capital facilities required in such fields as nuclear research, radio astronomy, and the scientific exploration of outer space, as well as proper attention to

such auxiliary matters as the dissemination of research results, opportunity for conferences and travel to scientific meetings, and communications with other scientists at home and abroad. How far successive British post-war governments have been from such an approach can be demonstrated by referring to their treatment of recommendations of the Advisory Council for Scientific Policy regarding the National Lending and Reference Libraries for Science and Technology, the shelving of the whole project for a Science Centre, and the futilities which in the name of economy have recently interrupted work on the Isaac Newton Telescope and the appointment of an administrator with no scientific, technological or legal training to the comptrollership of the Patent Office. Even the admitted shortage of scientists and technologists has not brought the Government to appreciate what is wrong, or to take the steps that would avoid the present wastage of man-power and lead to greater efficiency, and real and not imaginary economies.

On the question of priorities of effort as between one science and another, Dr. Waterman observes that no field of science should be excluded from encouragement and support. We simply do not know where the next capital discoveries may occur. The only distinctions that can be made as to relative values are in terms of contributions to understanding of our world, generality of findings, techniques available, current rates of progress, available skilled man-power, and occasionally neglected or over-emphasized special areas when so identified by the scientists themselves. The question of what way science can best serve the nation and all mankind is completely different, and involves an appraisal of national and human needs and the matching to them of progress in the several fields of science. It is almost exclusively a practical matter, concerning the applications that can be made from scientific discoveries and principles; and it may be remarked in passing that a main theme of the report of Prof. C. F. Carter and Prof. B. R. Williams on "Industry and Technical Progress" was that in certain sectors of British industry much more needs to be done to extend the application of existing knowledge.

National needs, Dr. Waterman points out, can be described in terms of broad essentials such as food, health, defence, transport, housing, communication, power and water, and in these the policy of the Federal Government of the United States is at present to place on its own agencies the responsibility for technology related to its own mission. Each agency, however, is also encouraged to conduct and support basic research in fields of science related to its work. Besides this work in its own laboratories, the Federal Government supports basic research in universities, research institutes and laboratories throughout the country, and the National Science Foundation was established in 1950 to further the support of basic research comprehensively and actively on all fronts.

The Foundation attempts to do this in various ways and by a wide range of institutions, seeking the diversity and flexibility that are essential to secure the conditions in which scientific effort is most vigorous and fruitful. By keeping the different agencies informed of each other's interests, the proposals received and any action taken, the Federal Government is enabled to follow the lead of the scientists in determining the research to be supported, giving a truly national policy for the encouragement of science. That policy does not indeed provide unrestricted research funds for institutions or their departments, and although support by scientific project is criticized in some academic circles, the balance of scientific opinion regards it as satisfactory, though Dr. Waterman suggests the question should remain open. There are some exceptions, such as agriculture, where the policy is more in line with that adopted for industrial research associations in Great Britain, and, more recently, in the assistance given to some institutions for medical research. Dr. Waterman stresses the traditional policy of avoiding Federal aid to education, which in an important field has now been substantially modified in the President's message on education, as Dr. Waterman indeed forecast in his own statement. There are other questions, too, which he suggests need attention: the direction and the degree in which the Federal Government should extend its support for science, including the increase of research activity in its own laboratories; the advisability of establishing federally operated general research laboratories; and the way in which any necessary further support for training in science should be given.

Dr. Waterman stresses the over-riding urgency of prompt, effective and permanent measures in these matters; but no less clearly he points to the utmost importance of new measures or modification of existing measures and policy having the understanding and support of the people. Effective measures to strengthen education in science and technology and to increase the national research effort cannot be taken in a democracy without the full support of its citizens. While one outcome of an expansion of technical and technological education and of the development of a broad general education should be increased public understanding of its value and importance, we have to seek to promote that understanding simultaneously in order to secure the support and continuity which will permit those developments. The impact of society on science can be as important as the impact of science on society.

This latest annual report of the National Science Foundation does indeed emphasize the neglected truth to which Prof. E. W. R. Steacie directed attention in his Purvis Memorial Lecture last November, namely, that society ultimately controls technological innovation, and the vital question is whether the organization of government in Britain to-day is appropriate for the exercise of such control. Without, in fact, some understanding of science or particular technologies on the part of the administrator or statesman, it is improbable that he will appreciate the opportunities which potential technological developments offer, still less

that he will face the awkward questions and difficult decisions that may be involved, and embark on the task of public education which is essential if support is to be forthcoming for the necessary decisions and policy.

In this influence that society exercises on the direction of technological advance lies the great danger of party politics, particularly under the influence of mass media of communication. As Prof. Steacie remarks, science has the major influence on what is possible, but only a minor influence on what is in fact done. An increasing proportion of the work of the National Science Foundation appears to be directed towards increasing the influence of science; and the development of Anglo-American co-operation in research and development, in the field of defence and elsewhere, depends ultimately on the extent to which, not only in the United States but also in Britain and in her partners in the North Atlantic Treaty Organization, the influence of science and technology on practical affairs and policy can be extended. We have to promote the will to use science and technology aright; and it is frightening that when the elements of control over our environment are within our grasp, we do not choose to use them.

Prof. Steacie's lecture does more than direct attention to some of the implications for the structure of government to-day. He sets science in the right context in relation to the technology of defence and to the question of education for this technological age. He rejects the idea that all scientists should be classed as second-rate citizens, and he pleads for a sane attitude towards specialization and discounts the pursuit of the argument of science versus the humanities. Somehow we must give the future leaders of society a general idea of the aims and methods of science, the lack of which is often a dangerous factor in our situation. He condemns the tendency, illustrated, for example, over the launching of artificial Earth satellites, to treat scientific advance as a race, with emphasis on nationalism, and, no less forthrightly, the consequent major importance attached to the keeping of secrets, with grossly exaggerated security measures.

The Purvis Memorial Lecture and the National Science Foundation's report both demonstrate how much common thought there is in Canada, in Britain and in the United States. While, however, each country may have much to learn from the other, the essential conditions of scientific and technical advance are independent of national boundaries; the establishment of those conditions and the administrative structure required to create and nurture them are problems for each national administration, and indeed for all those citizens, whether scientists or technologists or not, who are concerned with their country's economic and industrial future, its social welfare or its security. Both Prof. Steacie and Dr. Waterman, however, in challenging further thought as to the adequacy of Britain's present institutions, seem to point to the opportunity which a body such as the Parliamentary and Scientific Committee has of playing an increasing part in directing attention to problems and stimulating fresh thought about methods and needs.

There is welcome evidence that this is being done. The Committee has already taken action regarding the recent appointment of the comptroller-general of the Patent Office and on the payment of rates by scientific societies. The discontinuance of the Isaac Newton telescope and the question of scientific libraries are matters that fall well within its scope of action within recent years, particularly in relation to scientific and industrial research. The Committee this year heard authoritative addresses on space satellites and relevant matters, and on the use of thermonuclear energy at power stations. Such addresses might well suggest a re-assessment of national power policy in terms of the increase in capacity of the nuclear power station in relation to capital cost. The implications of these developments for both the man-power and capital invested in research and development require consideration from a wide national point of view, and especially with reference to the resources in capital and man-power already collected in industrial groups.

It is not suggested that the Parliamentary and Scientific Committee could do all that is required; but if it enjoyed strong support from scientific and professional institutions, with that of members of Parliament alive to the issues involved, it should be able to insist on public discussion at a level high enough to be embarrassing to any Government which sought to ignore the facts. With that, however, must go a continuing task of public education to create understanding which will support the policies required. Of the opportunities and responsibilities which confront the individual scientist and technologist, as a professional man and a citizen, the Purvis Memorial Lecture and the National Science Foundation report, like the recent annual report of the Parliamentary and Scientific Committee, give clear indications.

TECHNOLOGY: 1500–1750

A History of Technology

Edited by Charles Singer, E. J. Holmyard, A. R. Hall, and Trevor I. Williams. Vol. 3: From the Renaissance to the Industrial Revolution *c.* 1500–*c.* 1750. Pp. xxxvii+766+32 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1957.) 168*s.* net.

THE third volume of this monumental work, produced under the same editors with the continued assistance of Imperial Chemical Industries, Ltd., carries the story from the Renaissance to the dawn of the Industrial Revolution, and maintains the high standard of the earlier volumes already commended in *Nature* (176, 182; 1955: and 179, 709; 1957).

As before, the matter is not strictly confined to the dates given, and indeed the treatment of cartography, the calendar, town planning, and precision instruments extends back two thousand years or more.

The most important event of the period was the invention of printing in the second half of the fifteenth

century, which is admirably described in a chapter by Michael Clapham. The resulting flood of printed books accelerated technological progress by bringing about the rapid diffusion of knowledge. It also led to the attempt to re-discover ancient techniques and thus led to new knowledge. An additional consequence is that historians are able to draw on the new technical literature, and the wealth of material available in such writers as Biringuccio and Agricola and in the "Books of Trades" culminating in the great French "Encyclopaedia" both reduces the relative importance of archæological evidence and faces the editors and authors with difficult tasks of selection.

Corresponding with the expansion of the general knowledge of the educated man occurred the expansion of the Western world with the voyages of exploration made possible by the development of the full-rigged ship described in the chapter by G. P. B. Naish. This raised problems of navigation which could only be solved by the successful application of science. It was in the field of navigation, surveying, and time measurement that scientific solutions were first required, and the art of instrument-making which arose was later of great service to science itself in making possible the provision of optical instruments and other physical apparatus such as thermometers, vacuum pumps, and electrostatic machines. These topics are extensively treated in two chapters on cartography, survey and navigation by Charles Singer, D. J. Price, and E. G. R. Taylor; in two chapters on precision instruments by D. J. Price; and by H. Alan Lloyd on mechanical timekeepers.

The increased consumption of wood for shipbuilding and also in the extraction of metals led to the increased use of coal and made the problem of mine drainage more urgent, with the ultimate consequence of giving rise to Newcomen's invention of the steam engine. Although its advent thus falls within the period of this volume the steam engine is not discussed, since its main impact on society came later. Coal mining is treated by J. U. Nef, and Cyril Stanley Smith and R. J. Forbes write on metallurgy and assaying. Pumps are described by A. P. Usher in his chapter on machines and mechanisms.

In the period under review the northern European countries with their access to the ocean and their abundant sources of coal and metalliferous ores came to the fore and thus the centre of technological advance was displaced from the Mediterranean region where it had been since antiquity. North-west Europe was the region where the majority of the land drainage and reclamation works, described by L. E. Harris, and the canal construction, described by A. W. Skempton, were carried out.

The scientific approach was of value in the chemical industry as is shown by F. W. Gibbs, but it did not by any means always succeed in transforming craft methods. Thus dynamics was of no assistance in gunnery without the requisite precision-made equipment to profit from it, though much experimentation to improve gun construction took place, as is described by A. R. Hall in his chapter on military technology.

R. Patterson continues his account of the textile industry in which attempts to achieve mechanization fell short of success except in the ribbon loom and the knitting machine. The chapter on figured fabrics by the late J. F. Flanagan seems to be somewhat outside the scope of the book since the subject is more a matter of art than of technology. The same may be said of town planning by Martin S. Briggs, who has also contributed a chapter on building construction. A branch of the latter subject is given detailed treatment by S. B. Hamilton in his chapter on bridges.

R. A. Salaman writes of tradesmen's tools and their specialization and, with J. Geraint Jenkins, gives a detailed account of the trades of the wheelwright and the cooper. The latter author, with Olga Beaumont, contributes a chapter on farm tools, vehicles, and harness. Other contributions are on food and drink by R. J. Forbes, windmills by Rex Wailes, glass by R. J. Charleston and L. M. Angus-Butterworth, and the calendar by Sir Harold Spencer Jones.

The volume is well provided with text figures, many of which are, as before, drawn by D. E. Woodall.

K. R. Gilbert

NUCLEAR ENGINEERING

Selected Papers from the 1st Nuclear Engineering and Science Congress

Held at Cleveland, Ohio. Edited by D. J. Hughes, Stuart McLain and Clark Williams. Vol. 1: Problems in Nuclear Engineering. Pp. vi+365. Vol. 2: Reactor Operational Problems. Pp. ix+278. (London and New York: Pergamon Press, 1957.) £6 each volume or £10 the set.

THESE two volumes contain a selection of the papers presented at the first Nuclear Engineering and Science Congress held at Cleveland, Ohio, during December 12–16, 1955. This Congress was organized by the Engineers' Joint Council in order to present to American engineers and scientists information made available earlier at the International Congress on the Peaceful Uses of Atomic Energy at Geneva and additional information on engineering subjects. The delay between presentation and publication of papers in such a rapidly growing subject is regrettable.

Binding and printing are good apart from a few typographical slips. Some of the illustrations are unsuitable for reproduction but this is presumably the fault of the authors rather than the editors.

Each of the two volumes is divided into four sections, Volume 1 being devoted to site selection, materials, design and heat transfer, while Volume 2 covers waste disposal and radiation hazards, chemical processing, reactor physics and control and instrumentation. Almost all the authors of the eighty-eight papers are from the United States but there are one or two papers from the United Kingdom and Canada. The title of the first volume, "Problems in Nuclear Engineering", appears to be reasonably representative of the contents but that of the second, "Reactor Operational Problems", is ill-chosen since only about one-eighth of the book is devoted to reactor operation, the remainder being mostly concerned with chemical problems.

As is to be expected in a collection of conference papers, each of which must stand alone, there is much repetition of introductory and background material. For example, at least half the papers devoted to site selection, safety and economics in Volume 1 tell us that humans must be protected from the radiations emitted by nuclear reactors. One paper uses well over two hundred words to prove arithmetically that no generalization can be made about the number of people who might be involved in a reactor incident. This could be more easily tolerated if the arithmetic were correct. Perhaps the

most interesting paper in this section gives an account of a logical method of site selection by Topping, although one is struck by the apparent absence of objections by bodies concerned with the preservation of amenities.

The nineteen papers on materials form a reasonable discussion of the problems involved in selecting, making and fabricating suitable reactor materials. Some of these papers have a wealth of data in them although there are also some surprising omissions. For example, a paper by Johnson on ceramic fuel for nuclear reactors includes a table describing the change in thermal conductivity of a wide range of ceramic materials after irradiation by neutrons, but all information about uranium and thorium ceramics is omitted. The paper by Huddle on the oxidation behaviour of reactor materials is the most readable in the whole of Volume 1 and is the only paper which is an outcome of work on gas-cooled reactors.

Of the eleven papers included in the section on design, two are merely reviews of nuclear engineering and technology literature. The remaining nine include one by Kasschou describing generally the U.S. Army Package Power Reactor, while the other papers confine themselves to particular aspects of reactor design; but there is none directly relating to gas-cooled reactors.

The heat transfer section of Volume 1 is short, having only five papers, but two of these, one by Carbon, Gilbert, McNutt and Neider on steam generation in a reactor and the other by Miller, Byrnes and Benforado on heat transfer to water flowing parallel to a rod bundle, contain many useful experimental results. A paper by Alexander describes how the amount of heat produced in the fuel, cans, moderator and other reactor materials may be estimated. It is unusual to find this subject discussed in such detail at a conference and it is a great pity that the author did not include a worked example for illustration.

The first section of Volume 2 contains eleven papers under the heading of waste disposal and radiation hazards, among which those by Hatch and Regan and by Warde and McVay deal with the disposal of radioactive wastes by fixation on baked clay or sintered aluminium oxide. In spite of these and other discussions of sophisticated methods of disposal, the storage of solutions in tanks appears to be the only method in large-scale use, and Wilson discusses its economics. Monitoring and decontamination of water are discussed by Setter and Goldin and by Morton and Straub, respectively, and Eisenbud describes the stations of the monitoring network for fall-out in the United States.

In the second section there are papers on aqueous and organic liquid processing of spent fuel. There are also discussions of dry systems using the distillation of volatile fluorides, by Hyman, Sheft and Katz, by Page, Raseman, Scarlett and Goodman, and by others. Dwyer writes on fused-salt extraction of uranium-bismuth liquid fuel, and pyrometallurgical processing is discussed by the Argonne Laboratory staff. The engineering design of an aqueous plant which can be decontaminated to permit direct maintenance is described by Kennedy and Reid.

The third section contains nine papers devoted to experimental and critical assemblies and reactor physics. The use of a travelling ion chamber connected to a recorder to obtain the exponential flux distribution in a heavy-water system is described by Towler and Wade. Another paper describes an exponential facility in which small samples of particular lattice systems can be tested in a cavity enclosed by a standard lattice array. Two papers mention work on the EBR1. Kato, Kirn and Redman measured conversion ratios by activating foils of uranium-235 and uranium-238, and Crouthamel and Turk estimated fission and conversion rates by chemical analysis of suitable fission and neutron capture products.

The final section contains two papers on instrument developments by Pearson and by Bryant, Carlson, Curtis and Kaufmann, and one on reactor instrumentation experience at Chalk River by Siddall. It also includes a paper on design experience of pressurized water-cooled reactors at Westinghouse by Hamilton, Grace, Meyer and Wilson. Theoretical papers on the reactivity value of multiple control rods and on power reactor control are contributed by Murray and by Van Rennes, Simons and Gray respectively.

B. Cutts
G. R. H. Geoghegan

SOME ASPECTS OF BIOPHYSICAL CHEMISTRY

Biophysical Chemistry

By John T. Edsall and Jeffries Wyman. Vol. 1: Thermodynamics, Electrostatics, and the Biological Significance of the Properties of Matter. Pp. xv + 700. (New York: Academic Press, Inc., 1958.) 14 dollars.

It is unfair to the cooks to give a final judgment on a meal half-way through, and for this reason impressions of the present volume may be modified when the second volume appears. The book is based on a course of lectures on the physical chemistry of biochemical systems which the authors have given at Harvard, and is clearly intended for students who are going to be concerned with studies of biological materials. It assumes little or no prior knowledge of physical chemistry—in any event, it deals with thermodynamics from first principles and has chapters on electrical conduction of aqueous solutions, and on acid-base equilibra, all of which are normally taught as simple physical chemistry. On the other hand, there is nothing about the kinetics of simple reactions, although the rate of dehydration of carbonic acid is discussed.

It seems to me that the aims of the authors are rather confused. Certainly in Great Britain it would be better to assume that all students who are going to concern themselves with the physical chemistry of proteins will have had an elementary course in physical chemistry, which would normally include elementary thermodynamics and its application to aqueous solutions as well as the basic studies of kinetics. If these were omitted, the present volume would not only be much shorter (and cheaper) but, by concentrating on biological applications of physical chemistry, it would avoid repeating the ground covered in numerous other works.

One can understand the difficulty of deciding where to begin but, surely, in starting with first principles, the authors have gone too far. They are postulating the existence of students who have decided to study 'biophysical chemistry' at the very start of their physical chemical education. I find it difficult to believe that this *avis mirabilis* exists.

If one can judge the contents of the whole work from this volume, together with the announced ten-

tative contents of Volume 2, it might be fair to suggest that the title should be "Chapters in Biophysical Chemistry". Although some subjects (those in which the authors are particularly interested) are discussed in detail, others are scarcely mentioned. Enzyme processes are only briefly mentioned under the binding of molecules to proteins. Diffusion is not included in the elementary theory, suggesting that the authors think that diffusion processes are of no importance in biological systems. Under polybasic acids one might have expected at least some account of the titration of nucleic acids, and although hydrogen bonds get fourteen entries in the index, there is no mention of hydrogen bonding in deoxyribonucleic acid.

Nevertheless, many libraries will be glad to have this volume on their shelves for the accounts of specialized topics such as the dissociation and dielectric properties of amino-acids, peptides and proteins, and for the excellent account of protein – ion interactions. J. A. V. Butler

HOMAGE TO THE HERRING

The Herring and its Fishery

By Dr. W. C. Hodgson. Pp. xiv+197+9 plates. (London: Routledge and Kegan Paul, Ltd., 1957.) 25*s*. net.

STATES have arisen and fallen, fortunes been made and lost, scientific reputations built up and humbled, through this lowly fish. Beauty is framed in pearls from its scales, art created from its dead body, heroism fashioned in the men who catch it.

It is fitting that the herring should have honour done to it; and in this book Dr. Hodgson—than whom there is no one better qualified—does just this in full and honest measure, and in a refreshing manner.

When M. Graham's "Sea Fisheries" (London, Arnold, 1956) appeared marine biologists were quick to note that the herring—although it had been so intensively studied—had no special chapter. It was perhaps natural then to hope that Dr. Hodgson would make good this deficiency, and that his treatment would make it an acceptable companion for that of his former director and colleague of long standing. This it is not. It has no bibliography, few references, and gives little help to the reader who wants to inquire further. But it remains a good book.

Two statements have recently come from the Lowestoft Fisheries Laboratory: one is in this book (p. 73), and is "Life to-day is ruled by science"; the other, on the dust-wrapper of "On the Dynamics of Exploited Fish Populations" (R. J. H. Beverton and S. J. Holt. H.M. Stationery Office, 1957), is "Science is prediction". These two statements and the logical consequences which flow from them are no more true to-day than they have ever been; but they seem to have determined much of Dr. Hodgson's attitude to his subject, and shaped the course of his researches.

He paints a clear picture of his methods of age determination, of the assessment, composition, and recruitment of stocks, of the possible origins and migrations of the shoals providing the major fisheries, and leads up by closely argued reasons to the basis of his predictions, ending in an admission of failure. It is hard to see how all this could be written without even a mention of Ford, Storrow, Farran, Holt, Cushing, Burd, and many others who have studied these problems so extensively.

In conclusion, he decides (p. 177) that only in "natural causes and fishing" is the responsibility for the "collapse of the East Anglian fishery" to be sought. He rejects the first, and accepts that it is the growing exploitation of the immature fish on the "Dogger nursery" for conversion to meal for animal feeding which is the principal agency in this collapse. Many agree with him; but others, who also accept that fishing activity is the responsible agent for the decline, have different views. There is, moreover, the insidious menace of pollution, the danger of which to sea fisheries in contained areas such as the North Sea remains almost wholly unsuspected even in the most enlightened quarters, and which he apparently has not considered. H. O. Bull

A MELANESIAN URBAN COMMUNITY

The Great Village

The Economic and Social Welfare of Hanuabada, an Urban Community in Papua. By Prof. Cyril S. Belshaw. Pp. xviii+302+8 plates. (London: Routledge and Kegan Paul, Ltd., 1957.) 30*s*. net.

IN immediate contact with Europeans in Port Moresby, capital town of Papua—which is administered by Australia—there lives a community of indigenous Papuans. This interesting account describes something of the social and economic life of these Melanesians, and discusses certain administrar tive problems that have arisen as a result of theiliving in an introduced environment. Their own culture has been severely affected by Western custom, and it has not always been possible for the Administration to find an acceptable substitute for the loss of a traditional practice. For example, living accommodation for the people of Hanuabada, "the Great Village", became an acute issue after the Second World War when the village, having been evacuated, was re-established. Thatched houses are not, however, satisfactorily replaced by buildings with an unceiled corrugated iron roof and wooden walls (but has any Pacific administration found the solution to the modern housing problem?).

The picture presented of this community to-day is a complex one. The villagers are Christians; yet they continue to practise sorcery and to worship the spirits of their ancestors. They have retained an urgent sense of the importance of ceremonial, as practised in the exchange of goods and in feasting; but whereas craft products like arm-shells constituted an essential element in exchange, these are now in part—though only in part—replaced by cash; and the monetary substitute has come to be accepted. Cash is now habitually used also for purchasing some of the articles required for presentation on social occasions, such as weddings and deaths; and cash itself is similarly used as a gift. This demand for cash urges those in need of it for these purposes to go out and work for monetary reward. But the point to note is that cash has only partially replaced the ceremonial products customarily used. Again, the traditional dancing ceremonies—frowned on by mission supporters as being against the Christian moral code—are performed less frequently now than hitherto, and contemporaneously there has been a decline in agricultural production; the nexus here being that feasting was and is an essential accompani-

ment of the dance series held in honour of some person or to celebrate some local occasion. Clearly additional food must be forthcoming for such events. It could not be bought with cash in earlier times : it had to be produced, and this encouraged and increased agricultural activity. But with the decrease in dancing has come a decrease in agricultural production. At the same time the villagers' assessment of the value of cash appears to be immature. They are prone to spend it on social requirements, such as ceremonial payments, to the detriment of their nutritional needs ; and the Administration's effort to improve their health conditions has met with a resistance backed by generations of conservatism towards change.

These few specimens from the descriptions in the survey can be summarized in a sentence : where the people have assimilated an element of Western culture they have not assimilated also its associated characteristics and institutions (F. C. Bartlett, "Psychology and Primitive Culture," Cambridge, 1923). This accounts to some extent for their present pattern of culture being made up of indigenous and European elements side by side. Where this close association of cultures exists it is to be expected that the entity of the less dominant one will suffer. That has happened in Hanuabada, and its people are not now enjoying the best of either.

But there are some signs of a brighter future. They seem to realize that a complete acceptance of Western custom is beyond competition. This may be a good feature in their mental attitude if it does not altogether stifle their ambition. They have shown themselves competent to administer co-operative societies on modern lines ; and administrative ability—and integrity—should stand them in good stead for any job requiring responsibility. Despite their comparatively low income they do, in fact, save money for specific purposes, even though the original incentive to save may be conveniently overlooked if an unexpected call for money arises for some quite different purpose. On the moral side, the people appear to have been attracted by the Scout movement and this, apart from its other intrinsic merits, has contributed towards good race relations with Europeans.

From an anthropological point of view the amount of detail that Prof. Belshaw has given is not consistent with its importance under the various headings of his subject. More could profitably have been included on women's customs (pp. 162 *ff.*)—very rightly collected by his wife—since absence of such knowledge hampers any administration in its ability to guide their advancement compared with the guidance for menfolk, of whose customs a far greater knowledge is available ; and the women's position in a society at any given time is often a criterion of its development towards an enhanced level of living. Another criterion of welfare in its widest sense is the rate of infant mortality over a period. The figure is high for the year when the survey was done, but it would have been helpful to know the trend of the infant mortality-rate. It is a pity that more material for the survey was not obtained in the vernacular and that so much reliance was—apparently—placed on the opinions of the three Papuan officials "without whose services the research could not have been completed in its present form" (p. ix). Comment by Hanuabadans on their own welfare as they see it now and in the future would have added to the value of the survey. If Prof. Belshaw had had longer experience in the British Colonial Service he would probably have appreciated the substantial difficulties of the Administration in Papua in its endeavours to improve the lot of the Hanuabadans. His advice to the Administration and criticism of its decisions might have been more appropriately confined wholly to a final chapter instead of being scattered throughout the book. The sixteen photographs could have been clearer and more illustrative of the text.

"The Great Village" is the first account of its kind to deal with this part of the Pacific. Coming from a trained anthropologist, the Administration will no doubt welcome it as a painstaking and independent survey of modern conditions, and it is a book that should well repay close study by all whose interests take them to work in Papua, particularly those with administrative interests. It has the added advantage of being a factual, first-hand record of the 'welfare anthropology' of the Hanuabadans at a time when they are constantly subject to changes imposed from outside.

G. K. Roth

GALILEO AND THE HOLY OFFICE

The Crime of Galileo

By Prof. Giorgio de Santillana. Pp. xvi + 339 + 8 plates. (London : William Heinemann, Ltd., 1958.) 30*s.* net.

THE literature on the process of the Holy Office against Galileo is enriched in this book with a most noteworthy contribution. Prof. G. de Santillana, a scholar who has earned an international reputation by his books and articles on the history of science, has reconsidered the whole much-debated issue, making use of all the well-known documents and of numerous little-known ones, which are brought here into the discussion for the first time. By studying all these with the utmost care and acumen he has succeeded in throwing fresh light on several dark places and in solving various enigmas in the course of the affair. He will be the first to acknowledge that a great number of questions may still be asked which are probably destined to remain unanswered for ever. This, however, does not detract in any way from the great merit of having presented us with a wholly original view on one of the most important and interesting conflicts that has ever arisen in science. No one who wants to build up for himself a really justifiable opinion on this conflict can afford to leave the book unread.

Prof. de Santillana is a man of remarkable erudition, not only in the field of science and its history, but also in those of general history, literature, art and philosophy. With all these attainments merged into a general culture, one need not wonder that they appear in his writings again and again in the form of reminiscences and allusions which enhance the attractiveness of the story. However, I am sometimes afraid that the author tends to over-rate the intellectual capacities of the average reader.

The same remark applies to the numerous comparisons between certain aspects of Galileo's case and analogous situations in our own time. There are several allusions to contemporary American issues which the foreign reader may not always be able to appreciate. In so far as he is able to do so, however, he will admire the author's broad point of view, which allows him to present the process against Galileo as a particular case of a perennial conflict of scientific endeavour and social authority.

E. J. Dijksterhuis

A Guide to the Literature of Chemistry

By E. J. Crane, Austin M. Patterson and Prof. Eleanor B. Marr. Second edition. Pp. xv+397. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 74*s*. net.

WHEN the first edition of "Crane and Patterson" was published in 1927, it was, with the exception of the much slighter "Introduction to the Literature of Chemistry" of Dr. F. A. Mason, published three years earlier, essentially a pioneer work. It quickly met a recognized need and for a decade or more was unchallenged. If there are now other works that may meet the needs of British chemists more effectively, though probably not within two covers, that first edition also has given the names Crane and Patterson an honoured place in the literature of chemistry. It is no disparagement of the work that Prof. Marr and Dr. Crane have put into the preparation of what is virtually a new book to suggest that for British readers the second edition is unlikely to have the same appeal as the first: the changes arise out of the immense expansion of chemical literature, and considerations of space alone may well have dictated an appeal to the American chemist rather than to his British colleague.

The plan of the book is essentially unchanged and the chapter headings are unaltered, with the addition of new chapters on government publications and trade literature, but it is, as has been said, virtually a new book. Omission of the "Select List of Chemical Books" is the main change responsible for the reduction from 438 to 397 pages, and although it would have been impossible, within the limits of a single volume, to bring that list up to date, the book loses something of its appeal in consequence, and the first edition will retain some permanent value, particularly since in the treatment of historical literature the book is relatively weak. Criticism might be made on a few points of detail: for example, under biographical works, some help could have been given in tracing obituary notices, the indexing of which, to say the least, is often fortuitous. Nevertheless, this second edition, like the first, displays the full scope of chemical literature and affords sound guidance to British and American chemists alike in handling a literature search. R. Brightman

Engineering Materials, Machine Tools and Processes

By W. Steeds. Third edition. Pp. xi+426. (London and New York: Longmans, Green and Co., Ltd., 1957.) 35*s*. net.

FOURTEEN years have elapsed since the publication of the second edition of this useful handbook of workshop practice. Various additions and alterations have been made to deal with newer processes and methods that have proved themselves during those years, and have increased the size of the book by twenty-five per cent. The pattern of the book is unchanged, except for a new chapter added at the end. This is entitled "Transfer Machines and Automation" and in only twenty-four pages deals with some of the ways in which mass production in machining processes can be made more automatic and handling-time saved. Almost all of the other chapters have had changes; some are merely minor changes of order and others are additions. In the chapter on ferrous materials reference is now made to isothermal transformation diagrams and hardenability, but the reference is probably too brief for the average reader to grasp fully the meaning of these topics. There are various additions to the non-ferrous alloys, including a page on titanium. This review is not the place to catalogue all the additions, but notable ones are the Merchant theory of chip formation and air gauging systems. A thorough revision of references has brought the book up to date and there are many improvements in the photographic illustrations.

K. J. Pascoe

Theories of Nuclear Moments

By R. J. Blin-Stoyle. (Oxford Library of the Physical Sciences, Vol. 1.) Pp. vi+89. (London: Oxford University Press, 1957.) 8*s*. 6*d*. net.

THIS work is essentially a reprint of the valuable article by the author in *Reviews of Modern Physics* of January 1956, augmented by a chapter sketching the experimental sources of information on nuclear moments, and an appendix on angular momentum states in quantum mechanics. To explain electromagnetic moments we should in principle start from the nuclear Hamiltonian and the form of the electromagnetic interaction. In fact, we have only rough ideas as to what these are, and even if they were known, accurate calculation would be very formidable. Thus the theory is at present at the stage of using obviously over-simplified models wherever they will work, the different models required being linked in only a very qualitative way. Anyone desiring a quick survey of this surprisingly successful process cannot do better than read the volume under review. The accounts of the various models and their applications are very brief, but an extensive bibliography allows details to be pursued in the original papers.

The reviewer would have welcomed some discussion of centre-of-mass effects. These appear explicitly only in connexion with the quadrupole moment of an odd-neutron nucleus on the single-particle model. The formula given corresponds to a classical treatment of core recoil, and the dubious nature of such a treatment is not mentioned.

It is to be hoped, of course, that the progress of research will in a few years render this first edition obsolete. For this reason the use of paper covers, and the associated low price, are all the more commendable. J. S. Bell

The BBC Naturalist

Edited by Desmond Hawkins. Pp. 96. (London: Rathbone Books, 1957.) 8*s*. 6*d*. net.

THE valuable part played by the B.B.C. in fostering the widespread and growing interest in British wild life is undoubtedly an important factor in helping to build up a large body of public opinion favourable to the idea of nature conservation. In such features as "The Naturalist", "Birds in Britain", and "Look", the B.B.C. has brought many naturalists of repute to the microphone or the television camera, and the popularity of such programmes is something of a phenomenon in this technically minded age. The reviewer may be thought slightly cynical if he comments that many people quite incapable of recognizing a chaffinch on their doorstep may be perfectly familiar with the private life of a family of great black woodpeckers inside a tree-trunk in Germany, through the medium of television. Such an anomaly may be an unavoidable result of bringing natural history into the sphere of mass entertainment or mass education. However, recognition of the ephemeral nature of the spoken word has led to this excellent

publication, in which twenty-three broadcasting naturalists have written in their own personal styles of those aspects of Nature in Britain with which they are most at home. Peter Scott on painting waterfowl, Maxwell Knight on reptiles, James Fisher on tits and milk bottles, and Bruce Campbell on nest-boxes, with a score of others, are all here in print, helping us to enjoy and appreciate with fresh interest the wild life around us.

This book is well illustrated in colour and black-and-white, and at its moderate price deserves a wide circulation.

R. W. HAYMAN

Malaysian Parasites, 16–34

Edited by J. R. Audy. (Studies from the Institute for Medical Research, Federation of Malaya, No. 28.) Pp. vii+471. (Kuala Lumpur: Institute for Medical Research; London: Crown Agents for Oversea Governments and Administrations, 1957.) 42*s*.

THIS book comprises a set of papers on arthropod ectoparasites together with two on the known hosts of Malayan parasites generally and a useful review of the literature. The first paper is an interim review of the non-anopheline mosquitoes. (The propriety of treating these as parasites rather than predators is discussed by the editor elsewhere in the book.) Most of the book deals with mites but there is a paper on fleas and one on ticks. The papers on mites cover a certain number of non-Malayan species. The whole is an impressive tribute to the very active researches which have been pursued in this area since the War. The editor and contributors deserve every congratulation. The work is well and attractively illustrated and produced, although it is clear from the method of presentation that its stiff covers are not intended to disguise the interim nature of much of the contents. The taxonomist's road is a long one and the end is not yet. Most of the groups considered are at the beginning of the period of emergent order which follows on primeval chaos. As an example, it has been estimated that at least fifteen years will be required to raise the taxonomy of the Malayan culicine mosquitoes to the level prevailing in better-known parts of the tropics. The further stages of recognition and analysis of species complexes and, still later, the infra-specific analysis of individual species have been reached in only a very few small groups. Nevertheless, this is a heartening record of work in progress and a valuable reference book which no medical entomologist (or student of the vertebrate hosts) should be without.

P. F. MATTINGLY

Annual Epidemiological and Vital Statistics, 1954

Bilingual edition (French and English). Pp. 617. (Geneva: World Health Organization; London: H.M. Stationery Office, 1957.) 30 Swiss francs; 50*s*.; 10 dollars; 2,400 French francs.

THIS volume presents vital statistics for forty countries. Deaths by cause (International Abridged List, 1948) and the seasonal distribution of twenty-three major notifiable diseases are given in detail. A new section records the size and diversity of each country's medical services.

The proportion of all deaths due to senility and ill-defined causes is tabulated for the first time. Of the twenty countries listed Ceylon has the highest overall proportion, just under 20 per cent. France and Belgium have consistently higher proportions than England and Wales in each age and sex group.

The public health worker will find that this book raises some interesting queries. Why, for example, is mortality from accidental deaths (p. 378) higher in female than male infants in Northern Ireland, Finland, New Zealand, Japan and Ceylon, and lower in all others, and how can the high accidental male infant mortality-rate in Scotland be reduced?

Considering the complexity of the data the tables are well set out. It is, however, sometimes difficult to find the definition of a symbol. A few misprints occur, for example, 'explication' for explanation in footnote 6 (p. 53) and a transposition of the initial figures for the total and male population of the United States aged 65–69 (p. 27).

The most efficient use of the volume will be made by using it in conjunction with earlier numbers of this series.

S. J. KILPATRICK

The Mathematical Theory of Epidemics

By Norman T. J. Bailey. Pp. viii+194. (London: Charles Griffin and Co., Ltd., 1957.) 36*s*. net.

IN the theoretical development of each subject a stage is reached where research is hampered by the lack of a unified and logical presentation of past work. This book meets that need for epidemiology. It presents the mathematical analysis of epidemics based on deterministic and stochastic models. The older deterministic approach to the subject, though less realistic, is shown to be a useful precursor to the more difficult probability methods. Chain binomial theory (first used by Greenwood and more recently by the author) gives encouraging results in the analysis of household outbreaks. Earlier models predict the damping of recurrent epidemics. These are now more accurately described by stochastic processes. A full bibliography is given.

The book stresses the need for suitable stochastic models of endemics and for the proper collection of data to evaluate the assumptions and results of the theory. To this end formulae are given for the estimation of the parameters used in each model. The practical difficulties of estimating such necessary constants as β, the infection-rate, are not considered.

While this book contains much of interest to public health workers such information is generally difficult to find in non-mathematical language. It is accordingly more suitable for biometricians.

S. J. KILPATRICK

Family and Kinship in East London

By Michael Young and Peter Willmott. (Reports of the Institute of Community Studies.) Pp. xix+232. (London: Routledge and Kegan Paul, Ltd., 1957.) 25*s*. net.

THIS is the first of a series of reports issued by the Institute of Community Studies. It is based on interviews with 1,000 individuals living in Bethnal Green, London, a more intensive interview with forty-five married couples in that borough, and a study of forty-seven families originally living in Bethnal Green, but re-housed on the London County Council housing estate in Greenleigh. The first part of the study is concerned with kinship structure, and stresses in particular the important role of the wife's mother in the domestic life of the growing household. In the second part the authors study the reactions of families re-housed in Greenleigh and discuss the implications of their findings for future housing policy. The report is extremely readable, and combines the advantages of an anthropological field study with more rigorous statistical analysis. It is particularly welcome as an addition to the all too rare studies of normal family life in Britain to-day.

E. GREBENIK

THE NATIONAL PHYSICAL LABORATORY

THE National Physical Laboratory held two open days, on May 14 and 15. One hundred and eighty exhibits were on view to 3,250 guests of the Laboratory, who came from industry, the universities and Government departments. It was the first time that the Laboratory had been on show since the divisional reorganization, announced last February. This year, as an experiment, the range of exhibits was somewhat restricted, because the items chosen were selected to display work in certain chosen topics. For example, the exhibits shown by the Light Division all fell into three topics : optical instruments and methods ; standards and measurements of radiation, light and colour ; and research on vision. Work which did not fit into the topics selected was, therefore, not on display, but arrangements were made so that it could be discussed with the responsible officers of the Laboratory.

The Aerodynamics Division is investigating the problems of hypersonic flow, that is, at speeds in excess of Mach 5. Several new aerodynamic problems arise at such speeds, including intense aerodynamic heating resulting in dissociation of the working gases and, if the temperature is high enough, their ionization. For this investigation, shock-tubes are being developed which operate for about half a millisecond ; these obviate the problems of overheating the equipment. Surface temperatures and pressures are measured with rapid-response instruments and a schlieren optical system has been developed which records flow-density patterns around the test bodies using a camera of the Cranz-Schardin type (see Fig. 1). In addition to the shock-tube being used for the main programme of research, two small tubes have been constructed for work of a more fundamental nature on the properties of gases at high temperatures. One of these will be used to study the visible radiation spectroscopically in order to evaluate the gas temperature, the other to investigate the electron concentrations by means of micro-wave techniques. Some of the non-aeronautical work of the Division was displayed in the form of a small exhibition of models which had been tested in low-speed wind tunnels. There is a considerable demand for accurate information on the effects of wind on structures such as the B.B.C. television transmitting tower, suspension bridges, chimney stacks, blocks of houses and the aerial system of the University of Manchester radio telescope at Jodrell Bank. Similar work is carried out on the airflow around ships and buildings to ensure that the effluent from funnels and chimneys causes neither annoyance nor damage.

The Control Mechanisms and Electronics Division displayed a conditional probability computer. This is a form of 'learning machine'. It has five input channels and thirty-one units to store statistical information of the patterns presented by the inputs. When some statistical data have been accumulated in the storage units and one or more of the input channels is activated, the computer determines from the data whether such activation is usually accompanied by activity in one or more of the other input channels. If it is, the computer 'infers' that this activity is again present. The units which store the statistical information are counters which function by charging capacitors. These capacitors have deliberate slow leaks in parallel with them so that the computer's inferences are based more on later events than earlier ones. The demonstration showed the computer controlling a small mobile carriage which followed the boundary between black and white areas painted on the surface on which the carriage ran. The black and white areas could be effectively interchanged by reversing the steering mechanism, so making the computer learn the new conditions. It is hoped to develop the computer to a stage when it can function as an industrial control mechanism which will select optimum conditions by a trial-and-error learning process.

The Light Division has made significant advances in the techniques necessary to produce cheap, metrologically accurate diffraction gratings used for automatic machine-tool control. Gratings several feet long are being made by a photographic printing method of reproduction using the fine-grain emulsions already available in the Laboratory. Photographic techniques also open up the possibility of producing gratings directly from an interference pattern, so removing many of the possible sources of error in manufacture. The regularity of spacing would then depend entirely on the accuracy of the interferometer mirrors and the stability of the photographic emulsion during processing. This quite old idea, due originally to Michelson, has been made practicable by the development of both fine-grain emulsions and isotope discharge tubes used as monochromatic sources.

Fig. 1. Shock wave of flow around a sphere in the National Physical Laboratory hypersonic shock tube. Conditions (approximate): Mach 9 for equivalent altitude of 150,000 ft. and stagnation temperature of 6,000° K. (*Crown copyright reserved*)

Gratings 3 in. square with 30,000 lines per inch have been produced. Two gratings made in this, or a more conventional, way can then be arranged to produce moiré fringes while one of them, mounted on a carriage, moves over the other. The moiré pattern then controls the recording of a third grating mounted on the same carriage. This new grating is therefore smoothed by the integration produced by the moiré system over its effective aperture. Two such gratings are then used in the same system to produce another improved generation. In this way, the quality of the gratings can be improved until a limit is set by emulsion creep and considerations of mechanical and thermal stability.

In addition to these linear gratings, the Division demonstrated radial gratings with a moiré system to interpret angular movements. Eventually these gratings will be reproduced photographically, so providing the engineer with a simple accurate method of obtaining digitized information about both radial and linear movement.

The Mathematics Division exhibited DEUCE, its high-speed digital computer. The machine has solved some varied problems during the year, including work on cancer research, the examination of certain vibrational modes of molecules and the stability of aircraft in conditions of flutter.

The Metallurgy Division showed some work on the mechanism of brittle fracture. It has been found that brittle fracture occurs either by separation along grain boundaries or through crystals along cleavage planes. In the former case, two surfaces are formed from one previous interface, and the extra energy, corresponding to the difference between the new surfaces and the original interface, must be supplied for the fracture to occur. This energy difference is often a significant term; hence materials with low-surface and grain-boundary energies will have a greater tendency to fracture along the boundary than those with high energies. Experiments have been carried out with copper to which increasing amounts of antimony had been added. It was found that the addition of antimony reduced the interfacial energies of the copper—1½ per cent by weight lowers the energy by more than 80 per cent. It is thought, therefore, that the weakness at the grain boundaries can be associated with the effect of the antimony in lowering the interfacial energies of copper and, therefore, the energy requirements for fracture.

Niobium, with its high melting point, good strength at high temperatures and excellent ductility, is an attractive metal. It suffers, however, from the disadvantage that it easily absorbs gases at high temperatures, particularly hydrogen, with subsequent embrittlement. X-ray diffraction photographs of samples of niobium with known hydrogen contents have been taken. At low temperatures, some hydrogen is absorbed in niobium, and the rest is in the form of a hydride with a structure derived from the cubic lattice of niobium by a simple distortion. On heating, the degree of distortion diminishes and the hydride progressively dissolves in the niobium. At 300° C. a simple cubic solution of hydrogen in niobium remains. These changes may well have significant effects on the mechanical properties of the metal and on the amount of hydrogen contamination that can be tolerated.

The work of the two Divisions, Applied Physics and Basic Physics, was displayed under the common heading 'Physics'. There have been some advances in bomb calorimetry. The original National Physical Laboratory bomb calorimeter is unnecessarily precise for the determination of the calorific value of fuels, and the experiments conducted in it take considerable time. Hence, the Laboratory has built a copper aneroid bomb which dispenses with water as a thermal reference (Fig. 2). It needs only four temperature measurements in each determination and its lower thermal capacity enables experiments to be conducted more quickly. The aneroid principle is capable of high accuracy, and a third calorimeter with a silver bomb has been constructed to check the heat of combustion of benzoic acid, the common standard of all such determinations. The original calorimeter was recently used to measure the stored energy in graphite samples taken from the Windscale atomic pile by comparing the heats of combustion of irradiated and unirradiated samples.

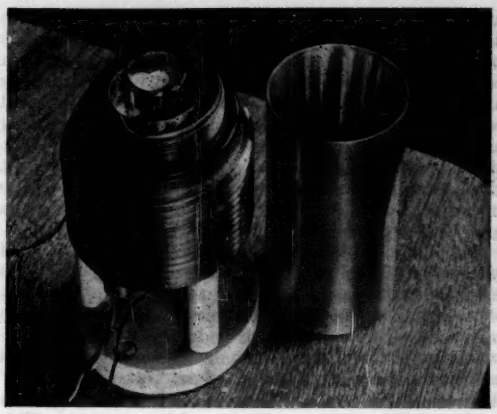

Fig. 2. National Physical Laboratory copper aneroid bomb calorimeter showing the platinum crucible, firing leads and shield
(*Crown copyright reserved*)

An elegant multi-channel pulse-height analyser was displayed. This instrument, when fed with amplified pulses originating, for example, from a proportional counter, will produce a pulse-amplitude spectrum. It was built in collaboration with the Control Mechanisms and Electronics Division concurrently with a similar instrument made by the Admiralty Research Laboratory, Teddington. The analyser operates by converting amplitude to time and then passing the signals of different duration into different channels. It will also provide the difference between two inputs or subtract the background signal measured over the same time interval as the total signal.

Among other exhibits was a demonstration of a possible technique for measuring absolute temperature by determining the Johnson noise generated in a resistor. Such a 'noise thermometer' is theoretically capable of operating over a wide range of temperatures and pressures. Its accuracy is limited by the internal noise of the input valves of the amplifier. It appears that a comparison of noise voltages to 0·05 per cent may be possible, and a resistor has been built with a low enough leakage at 1,100° C. to exploit this accuracy.

Marine engineers need accurate methods of determining the actual power absorbed by propellers. The Ship Division showed a new torsionmeter which can be attached to propeller shafts of 2–6 in. diameter without having to unship the shaft. The instrument uses strain gauges arranged in a four-arm bridge

attached by adhesive to the propeller shaft. The arrangement is such that it responds to torsional strains but not to bending strains. The signals are taken off the rotating shaft through silver-plated slip-rings and silver-graphite brushes. They are amplified and recorded on a null-balance strain meter. The ring assembly incorporates a revolution counter so that the rate of rotation of the shaft can be measured at the same time as the torque. The accuracy of the instrument is ± 1 per cent for torque determination and ± 0·2 per cent for speed of rotation.

The Standards Division incorporates the old Metrology Division and parts of the Physics and Electricity Divisions. It had a number of displays showing the value of interferometry, both optical and micro-wave, to science and industry. In 1960, the platinum–iridium bar which is the metric standard will probably be superseded by an 'intangible metre' defined as 1 650 763·73 times the wave-length *in vacuo* of the orange radiation of krypton-86. This standard will be not only reproducible in any laboratory, but also it is likely to be about a hundred times as precise as the present line standard. Interferometric methods used in conjunction with this new standard were demonstrated. The Laboratory announces the results of a new determination of the velocity of electromagnetic radiation—in this case not light but 4-mm. micro-waves. The velocity in free space *in vacuo* is 299 792·50 km. per sec., with a standard deviation of 3 parts in 10^7. The determination was made with a micro-wave interferometer which measured the wave-length of the radiation. The product of this and the frequency of the source, determined by comparing it with a quartz crystal standard clock, gives the velocity of the radiation. The actual distance over which the velocity was determined was only two metres. The result, with its applications to geodetic surveying, is a contribution to the International Geophysical Year.

To supplement the cæsium atomic standard of frequency, more accurate quartz clocks are required for long-term periods. Investigations have been carried out on the stability of a quartz Essen-ring operating at 4° K. Preliminary results suggest the damping is much reduced at this temperature and the temperature coefficient between 2° K. and 4° K. is less than 1×10^{-8}. The ring was immersed in liquid helium and the temperature was controlled to ± 0·001° K. by regulating the pressure. The stability of the oscillator may approach 1 part in 10^{11}. A problem to be solved is the replenishment of liquid helium without mechanical disturbance, and special liquid helium containers designed for this purpose were shown. A. J. Garratt

THE SPECIES CONCEPT AMONG VIRUSES

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THE term 'species' has been used to describe at least four different ideas:

(1) Linnæus's concept was close to the meaning 'a distinct kind of creature', that is, a group of organisms clearly separate from other groups of organisms, with no intermediates in between, and not itself divisible into distinct sub-groups.

(2) Geneticists consider a species as a 'genetic isolate' (with minor details of difference in definition) since—in organisms reproducing sexually—distinctness usually depends on absence of interbreeding with neighbouring forms.

(3) Palæontologists use the word in sense (1) extended in time, realizing that although obviously the species is continuous in time, with intermediate, ancestral and descendant forms, yet at any one instant the stock is distinct from others, no intermediates being extant.

(4) Systematists commonly use 'species' frankly as 'the most important rank in taxonomy below genus', and this must depend on subjective ideas as to what constitutes a genus, which (like the criteria for all higher ranks) are based mainly on intuitive estimates of degrees of similarity. Methods are, however, now being evolved for expressing this matter of similarity in a quantitative way[1,2].

There is as yet no general agreement as to which use of the term 'species' is best for general adoption. For viruses, however, only usage (1) can be seriously considered at the moment. Genetic recombination, a form of sexual reproduction, certainly occurs among viruses, but we simply do not know how common it is; we cannot therefore use the concept of genetic isolate at present in attempting to delimit species of virus. Many viruses are probably mutating and evolving more rapidly than higher organisms; at the same time, our knowledge of their past evolution is negligible; so usage (3) cannot apply. Ideas as to virus taxonomy are at present in an embryonic state, so we can as yet derive little help from usage (4).

Virus Nomenclature

At the last two International Congresses of Microbiology (Rio de Janeiro, 1950; Rome, 1953)[3,4], consideration has been given to virus classification and to the usefulness for viruses of a binomial system of nomenclature. As a compromise between two widely divergent views, a plan was put forward in Rome for a 'non-Linnæan' binomial system, provisional and less rigid than the orthodox system. Group names were proposed for some animal viruses and descriptions published: Myxovirus (Andrewes, Bang and Burnet[5]), Poliovirus (von Magnus, Gear and Paul[6]), Poxvirus (Fenner and Burnet[7]). Similar descriptions for a Herpesvirus group and for insect pathogenic viruses are in preparation.

Since their proposal in 1953 and the further publication in 1955, the names Myxovirus and Poliovirus have been widely used, but the 'specific' names have

been practically ignored, almost as completely as have various comprehensive proposals for Linnæan nomenclature of viruses. It would appear that at the level of the 'group', which may be tentatively regarded as equivalent to 'genus', agreed names may be useful, but that there is little enthusiasm or demand for Latin names for individual animal viruses.

'New' Viruses

There are other cogent reasons for re-examining the matter. Since 1953, exploitation of tissue culture and other techniques has resulted in the discovery of very large numbers of 'new' viruses.

(1) *The Coxsackie viruses.* Small viruses pathogenic for suckling mice, and isolated most frequently from human fæces. These are classified into group *A* with nineteen serotypes and group *B* with five serotypes.

(2) *Echoviruses.* This term originally denoted 'enteric cytopathogenic human orphan' viruses, but this meaning is already almost forgotten. They are related to Coxsackie viruses but tend rather to be cytopathogenic in monkey kidney tissue cultures and innocuous to baby mice. Twenty serological types are already known, but the group is probably not a homogeneous one. One (Echo 9) has properties shared by both the Echo and Coxsackie groups. A recent tendency is to group Echo, Coxsackie and poliomyelitis viruses together under the name of *Enteroviruses*[8]. Similar viruses have been recovered from fæces of cattle, monkeys and pigs.

(3) *Adenoviruses*, with eighteen serotypes, have been mainly isolated from the respiratory tract of man; they share a common complement-fixing antigen and some have been depicted in orderly array within the cell nucleus.

(4) *Arborviruses.* This term covers the ARthropod BORne viruses. Dr. J. Casals and Dr. M. Theiler have in their collection about seventy-seven different ones. Rather less than half of them can be put into one or other of three sub-groups, *A*, *B* and *C*, mainly on the basis of antigenic relationships. The remainder comprise a very heterogeneous assortment.

In none of these three or four virus groups is it possible at present to see that it would be rational to make divisions into species. Let us consider Casals and Brown's *B* group of arborviruses[9]. All are related by tests involving hæmagglutinin inhibition. The group includes the yellow fever, West Nile, St. Louis, Japanese *B*, Murray Valley, Zika, dengue I, dengue II viruses and numerous others. Yellow fever virus would be considered by most people to stand apart on the basis of its pathogenicity for the primate liver, but there appear no other good grounds why it should do so. Murray Valley fever has been given a separate name largely because of its geographical distribution, but it differs no more from some strains of Japanese *B* virus than those do from each other. Dengue viruses are divided into two serological types, but these have almost as much right to specific names as have Zika, Ilheus and others of the *B* group. The inter-relationships within the group are, in fact, of all degrees of magnitude. To call each isolate by a separate geographical or other name could lead to as much confusion as happened in the genus *Salmonella*, particularly if there were any implication that such names indicated specific rank.

A few groups such as Myxovirus and Poxvirus have proved amenable to an attempt at binomial nomenclature, though even with them the matter is not straightforward. After five years, however, it does not appear that any other group of viruses suitable for similar treatment is in sight. We have made a very preliminary attempt to compare, and if possible group, twenty-five viruses by means of an objective quantitative method[1]. This tries to group organisms by expressing their similarities quantitatively; each virus is compared against each other virus and given a percentage score on the basis of the proportion of characters common to the two. We compared twenty-five viruses and made use of forty-nine characters, choosing for convenience—and despite minor logical objections—those in which we expected a reasonably even distribution of + and − answers: such characters were none too easy to find. There proved to be so many gaps in our knowledge that for most viruses we could score only about twenty-five of the forty-nine characters. Some of the viruses we chose were expected to fall together; for example, three poxviruses, three myxoviruses and four arborviruses; the others were rather heterogeneous.

The analysis was scarcely very revealing. Those viruses which we expected to fall close together mostly did so. The three myxoviruses lay close to each other; so did the four arborviruses, and along with them, not unexpectedly, that of lymphocytic choriomeningitis; herpes simplex and pseudorabies proved to be very similar. The only surprise was that the three pox viruses chosen, vaccinia, fowl-pox and myxoma, failed to show evidence of very close relationships. No significant groupings appeared where none had been perceived beforehand. The analysis would doubtless have been more valuable if we had included more viruses and particularly if we had had full information concerning many more properties suitable for comparison. Further studies in comparative virology would be very helpful, but as things stand it seems difficult to make further headway at the moment along the lines put forward at the Rome International Congress on Microbiology. We do not feel competent to discuss how far the same situation exists with regard to plant viruses, but we suspect that it is not very different. Bawden[10] favours Mayr's term 'collective species' to mean a collection of clones having many features in common; but this may in fact not be very different from the 'group' in animal viruses. He feels that to attempt to classify plant viruses on a phylogenetic basis is at present quite impracticable. No worker on bacteriophages, so far as we are aware, has felt that our knowledge is sufficient to justify an attempt at comprehensive classification in this field.

To return to animal viruses, a fundamental difficulty is this: some viruses, such as measles and mumps, seem to be clearly distinct stable entities, but among the welter of other viruses, largely newly discovered, and often of doubtful pathogenic importance, they appear to be exceptional. One would expect on several grounds that viruses are evolving rather rapidly[11]; when one finds that most viruses do not fit tidily into species one's suspicions are strengthened. When factors leading to evolutionary change have long been stable, species are revealed as discrete mountain peaks; the equivalent of subaerial denudation has worn away deep valleys between them by eliminating poorly adapted clones. Where evolution within a group is still highly active we can see only ill-defined pimples and corrugations on a plateau.

If virologists use the term 'species' for viruses they should be clear in which sense they are using it: at present, usages other than the Linnæan seem to us quite unrealistic. We go further and suggest that at the present time the species concept should not be applied to viruses at all; further knowledge may, of course, change our ideas. Bacteriologists nowadays are becoming equally doubtful as to the proper application of the word 'species' in their field. Many botanists regard Linnæan names as having a usefulness only in a limited sphere; in the field of experimental taxonomy other parallel terms are required[12].

What, then, can be done to name and identify viruses? Some method of escape is needed from the confusion which results when authors use unrelated series of initials such as *YSK, CA, CCA, JH, EMC*. Perhaps virologists should continue with the Rome proposals for group names: names such as Adenovirus, proposed by *ad hoc* committees, fit in with these very well. We may, however, be wise to cease to force upon viruses latinized 'specific' names; numbered serotypes do well enough at present for adenoviruses and echoviruses; other systems of naming may have to be devised for other groups. Perhaps we should hasten slowly, concentrating on defining and naming 'groups'; but, below the group-level, only making such improvizations as seem wise in our efforts to clarify and codify this rapidly expanding field of knowledge.

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CONTROL OF EVOLUTION IN MAN*

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WHEN Darwin published his "Descent of Man" in 1871 he thought it better to discuss what had happened in the past, with results that could be seen, rather than venture into discussing the future. This task he left to Francis Galton.

Galton began with a point of view on human evolution formed by his medical training, his African travels and his study of Darwin's work[1,2]. On the basis of the cell theory he took a view contrasted with Darwin's, both on the inheritance of acquired characters, and on the distinction between one-egg and two-egg twins[3].

He noticed that like mates with like in man and thereby creates self-sustaining breeding groups. He also studied the genetic component of fertility and intelligence, and applied this principle to the study of natural and sexual selection in different social classes. His method has been effectively developed to show that the decline of governing classes is hastened by their choice for wives of infertile heiresses[4,5]. Similarly, he discussed migration and its effects, always assuming that men have to make culture before culture can be said to make men. He concluded that "the human race has a large control over its future forms of activity . . . for it can gradually modify its own nature". Galton thus foreshadowed a genetic interpretation of the structure and also of the history of society.

To-day, a number of advances may be traced to Galton's work. Intelligence tests[6] have indicated that the less intelligent individuals and populations can now propagate their like faster than the more intelligent[7,8]. This has not happened before in history or, we may say, in evolution[9]. In Holland, the United States, Tasmania and England[10,11] they have shown that migration modifies the intelligence of a community. The most active farmers move on to the best land. They exercise discrimination. They select their environment. Similarly, the migration from country to town and, as Galton pointed out, from the provinces to the metropolis, is reflected in the educability of the children.

Another application of Galton's views is to fertility. On one hand, consider the Hutterites. By selection for fertility together with inbreeding they have raised their average from 9·2 to 10·9 children per family[12]. On the other hand, consider Ireland. In 1847 the population reached more than 8 million with a density equal to that of England and Wales. It had multiplied six-fold in less than 140 years. Following a loss by emigration in 10 years of 1½ million, the population of Ireland has been almost stable for fifty years at half its peak number. Emigration, it seems, has selectively lowered the fertility of the people who remained and thus has led to the uniquely low and stable birth-rate in Ireland to-day.

Classical Genetics

To a student of genetics to-day, Galton's theories seem to be well founded. But at the time they rested on a basis of incalculable heredity. The rediscovery of Mendel in 1900 might thus have been expected to strengthen Galtonian and Darwinian theory. It did not do so.

For Bateson, to be sure, Mendelism at once clarified certain primary issues[13]. For the first time it showed that hereditary variation was largely invisible. A man might suffer from too little pigment in the skin or too much pigment in the urine through heredity although no known ancestor had suffered from it[14]. Heredity could be seen as responsible for the unlikeness of brothers as well as their likeness. In disclosing these primary paradoxes suddenly Mendelism had magnified the genetic, at the expense of the environmental, component in all variation. Not only the cards but also the process of shuffling was a manifestation of heredity.

* Substance of the Woodhull Lecture delivered at the Royal Institution on March 21.

Owing to the disputes between Bateson and the followers of Galton, however, the evolutionary aspects of the new advance were pushed into the background. The Mendelian design of experiment required pure lines and gene mutations of gross effect. Pure lines and gene mutations were therefore taken by Bateson, and later by Morgan, as the raw materials of natural variation. The model systems that resulted were easy to handle in theory but they gave an unconvincing account of natural variation, above all in man.

It was in this period that environmentalist explanations of human variation gained ground in the social sciences. Mendelism, unhappily using the word 'character' instead of 'variable', was too crude and naïve to explain the subtleties of human variation: they came to be left to the operation of spontaneous causes subsumed under the word 'culture'. It has even been argued that because culture can sometimes be socially *transmitted* it can never be racially or individually or genetically *created*[15].

Genetic Systems

Genetics has grown out of Mendelism in the past thirty years, by spreading down into the cell and up into the population. This growth has developed the paradoxes as well as the laws of heredity. In the breeding experiment we see the direct reaction of heredity with environment. In a fixed population we see what is there after the environment has selected the heredity. In a mobile population we see what is there after heredity has also, in its turn, selected the environment. The opposed agents are not independent: they interact in sequence; and the sequence with men and animals begins with a variable heredity.

Again, to the experimental breeder the unit of variation is the gene mutation. To the cytologist it may be an inversion or an interchange of a piece of chromosome; and to the naturalist it may appear as a polymorphism, a floating 'variety'[16].

The bringing together of these three methods of inquiry has now established that the bulk of natural variation is due to the mutually adaptive combining of mutations and structural changes; that the mutations themselves are of different orders of size; that in most of their activities they are the individually undetectable parts of multiple or polygenic systems; that genes expand or contract according to the size of the breeding group within which they are being exchanged. Not only this, but also polygenic systems are adapted to the range of variation of the breeding group within which they subsist. Their evolution is therefore itself subject to changes in the size and character of the breeding group. Genes and genotypes are therefore related to breeding groups and have to be considered together with them in examining the evolution of any species[17,18].

This transformation may be illustrated in the most successful field of human genetics. For fifty years the study of blood group antigens has proceeded on Mendelian lines. It has led to the most detailed account of geographical variation known in any organism[19]. Gradually, however, the structural complexity of some of the genes or super-genes concerned has been predicted by Fisher, and demonstrated by Race[20]. Independently, their physiological complexity has been predicted by Ford[21] on the analogy of polymorphisms in other animals. This complexity has now been demonstrated with selective and evolutionary implications by statistical studies of their relations with susceptibility to disease[22].

Lately the hæmoglobin genes have shown how malarial diseases have forced whole races of men to modify the composition of their hæmoglobin as a means of avoiding extinction. To do so they have had to introduce an adaptive polymorphism more drastic than that known in any other animal[23,24]; comparable indeed only with that of hybrid species of plants.

These relations, paradoxical or dialectical as they may be, mean that we have to begin our study of evolution in any organism farther back than we had thought necessary. In man we first have to examine the history of his breeding groups. Fortunately, however, they are better understood than those of any other organism.

Human Breeding Systems

For some thousands of generations until recently, man has been spreading over the Earth as, by his own evolution, larger areas became profitably occupiable by him. He still exists in simple societies the breeding habits of which, since they are found in all continents, are assumed to correspond with those of his common ancestors. Mating is limited not by his immediate fertility but by self-imposed rules rejecting at once close inbreeding and wide outbreeding[25].

The repugnance for outbreeding is, of course, common to all life. It has merely become more discriminating in man. The repugnance for inbreeding, on the other hand, is new. It has demanded more than discrimination. It must have arisen either from the experience (which is universally true) that unusual inbreeding yields an unusual proportion of defective recessive types in the offspring; or from the selection of races in which an instinctive reaction took the place of such an intelligent inference.

The combination of outbreeding and inbreeding must have always had, as it has to-day, a precise effect on the mating groups in which man exists. The effect is comparable only with what arises from the incompatibility of plant systems[26]. It means that within these groups three special properties will be favoured: hybridity, recombination and uniformity. We expect, and we seem to find, that where the group is small and stable these properties are soon established.

All these properties, it would seem, favour the immediate welfare of the group. They have, however, one important consequence for the future of the group: it is to discourage any genetic cleavage within it so long as its members live within range of one another. The group is homogeneous and its homogeneity is preserved by the outbreeding rules. Differentiation in social function, in occupation, will arise between the sexes and between young and old; but it will not arise spontaneously between genetic sections within the mating group. Pairs of such societies in Australia may even fuse and combine their marriage rules to allow of a new uniformity in the enlarged group[27].

In advanced societies we have parallels with the endogamy and exogamy rules of primitive societies. Neither, to be sure, is so rigorously maintained; and the breeding groups established can be shown, over thousands of years, to be of varying stability. But they are fundamentally contrasted with those of primitive societies in one respect. They are hori-

zontally stratified in groups or classes which meet but do not mingle. These classes, which come to work and think and speak[28] differently, co-operate by virtue of genetic differences which they preserve by not interbreeding.

To the rule that social classes cannot be preserved if they freely inter-marry there is one legendary exception, the Natchez Indian tribe. But the four classes described could not, in fact, have maintained themselves even in numerical balance if they had followed the rules attributed to them[29].

The development of social classes, beginning at the neolithic stage, has followed different lines in the main areas of civilization. Hinduism, Judaism, Islam and Christianity have diverged in their effects on the breeding system. Most striking is the contrast between India and the Middle East. In India a unity of religion prescribes a diversity of 'breed' or 'caste'. In the Middle East, since the triumph of a tolerant Islam, a multiplicity of religions guarantees a multiplicity of professional breeding groups. Underneath this contrast, however, the genetic principle is uniform. It is also quite distinct from the automatic systems of genetic caste distinction in the Hymenoptera[30]. Inter-fertile classes which work together without breeding together uniquely distinguish advanced human societies from all other forms of animal life.

If the breeding systems of primitive societies always favour uniformity or homogeneity in their genetic structure, how has stratification come about in advanced societies? One source is to be found in the nomadic communities of the Middle East. Tribes where sheikhly and slave castes are undeveloped have become different in their genetic character. Their differences are shown first in their mental and emotional character, and by derivation in the kind of work they do and the skill they acquire in it. From this differentiation of tribes their co-operation and commerce arise by agreement[31].

Such co-operation of racially different people has evidently been one of the bases of class differentiation wherever craftsmen and sailors, merchants and missionaries have wandered and settled[15]. But the foundations of class structure have been laid as much by conflict as by friendship. Governing classes owe their origins largely to conquest. Agriculture owes its development largely to slavery, and slavery also largely arises from conquest or piracy. "Bondmen" shall be "heathen" and "strangers" (*Leviticus*, xxv, 44–46).

On this view, introduced genetic differences, whether racial or tribal, have sown the seeds of social differentiation and the co-operation of dissimilar individuals out of which the richness of human cultural development has arisen. How have these seeds germinated? All stratified societies that have survived have permitted a limited inter-breeding between the groups: slaves could be freed, freemen ennobled and the Brahmin's offspring might sink to a lower social level. By legislation and by direct action, Roman emperors and Indian kings have controlled these processes with the intention of controlling evolutionary change. The development of class society has depended on the mixture of the materials brought together in this way, mixture subject to processes of mating, promotion and migration, all of them socially selective, and selecting differently in different societies.

In India, after some mixture leading to the formation of new hybrid castes, inter-breeding has often ceased. The genetic processes of diversification of a society have thus fossilized at a stage not far removed from racial mixture. In the U.S.S.R. and America strictly racial classes can exist together with a theory of classlessness; and old classes can dissolve side by side with a crystallization of a new class structure which predictably reconstitutes itself.

In these changes we know how valuable the mixture of groups must be in providing the recombination which releases variability. Conversely, how valuable a restriction of mixture must be, follows from the Mendelian principle that one act of crossing can undo the work of a hundred generations of faithful inbreeding. A steady release of variability, therefore, demands a restriction of crossing. If a small group like the Greek merchants of Chios[32], the Quakers in England or the Hutterites in Alberta were to preserve their character they had to inbreed. Thereby they reinforced the homogeneity of that character, their consciousness of it, and often their desire to preserve it.

On this genetic view our advanced societies are more complicated than anything envisaged by Galton. They are not races in an animal or plant sense. They are differentiated nations. Their differentiation may be appropriate or inappropriate to the needs of the time and in this we may see the genetic component in the rise and fall of empires. The differentiated classes may begin by differing on the surface; but they end by differing more under the surface like the cryptic species of plants and animals. Their ability to keep apart maintains civilization while their ability to mix allows evolution and promises survival.

Control of our Evolution

Man throughout his history seems to have been interfering with his evolution by most of his political acts and his social habits. What has been unconscious is bound now to become conscious. As we study the consequences of our actions we shall correct them; and as we introduce new actions we shall already be aware of their consequences.

How much do we know? We know that change in our breeding system has the effect of creating visible diversity of form. We know little of its effect on the invisible variables: intelligence and fertility, viability and resistance to disease. In our own population, I find, a change from outbreeding to inbreeding leads, as in other organisms, to depression, especially affecting the invisible variables. But it provides the means of rapid improvement, if we want improvement.

On the simpler Galtonian selective level the development of medical science has upset the world's population in quantity and also in quality. The qualitative changes affect race as compared with race, class as compared with class, and individual as compared with individual. Medical treatment of most genetic disabilities, except lack of intelligence, enables those who have been treated to survive and to reproduce when they would not otherwise do so. Those who were saved as children return to the same hospital with their children to be saved[33]. In consequence, each generation of a stable society will become more dependent on medical treatment for its ability to survive and reproduce.

Thus our control is changing the direction of evolution. We have to weigh its advantages and its disadvantages. Meanwhile, let us note a larger

principle: every branch of government in its own field controls the evolution of the people it administers. The punishment of crime affects the reproduction of the criminal class. Education affects the mating groups of those who pass through the system. Taxation and subsidies affect the relative numbers of children born in the different social classes and can be adjusted to vary the results over a wide range.

The governments of Augustus and Claudius seem to have been aware of the effects of regulating genetic diffusion between classes. Modern authorities with their more drastic actions are unaware of such effects. They are unaware because the actions themselves are directed, not to breeding, but to the present life of the individual and the present economy of the State. New processes, however, which are directed to breeding, are now attracting attention. Such are ionizing radiation, sterilization and artificial insemination.

The classical geneticist is much impressed by the consequences of ionizing radiation in inducing mutations. When induced in the ripe sperm of *Drosophila*, and followed by two generations of brother–sister mating, these mutations lead to dire results. On man, living and mating at large, however, we do not yet know what the lasting genetic effects of such radiation may be[34]. So far as we can foresee, they would be like the effects of an increased frequency of cousin marriage in an unaffected population.

The inverse of this problem is shown us by the introduction of the practical measure of the sterilization of genetically, usually mentally, defective individuals. This kind of evolutionary control has been used for sixty years in the United States and for thirty years in Scandinavia. Here is one way, a negative way, in which governments are assisting in the propagation of intelligence. The practice is increasing[35].

A positive means of propagating intelligence is provided by artificial insemination[36]. When this technique was first introduced, pedigree cattle breeders foresaw great dangers to their own interests, and their foresight has been vindicated. The new method has undermined the value of the old criteria in cattle breeding. Now man, as we have seen, has a self-maintaining breeding system of a uniquely complex kind. It cannot be reduced to the steady formulæ of a cattle-breeding system. Artificial insemination from a donor (AID) is therefore likely to have more diverse consequences for man than for a domestic animal.

What are these consequences? A third party is introduced into the control of the breeding process. If he is aware of its genetic consequences he may, like the Russian landowner who bred his serfs for beauty[37], be able to render a service to society. Moreover, since his activities are likely to be limited to the remedying of sterile marriages, we shall have time to judge their results before any danger arises from them. But if his results are secret there will never be any possibility of assessing or correcting them.

There is one respect in which assessment would be useful. In the past, the rigidity of human breeding systems has been mitigated by illegitimacy. From William the Conqueror to Abraham Lincoln, illegitimate class-crosses, such as rarely arise through marriage, have produced men out of the common run[38]. In advanced societies illegitimacy is declining; but through artificial insemination the laws of legitimate, that is, assortative, mating might be evaded with advantage to the community. For single individuals can alter the course of history or of human evolution.

The Future

Man controls his own evolution by two general methods. One is through the selection which changes the character of the world's population in every generation. The other is through the processes of inbreeding or outbreeding by which variability is preserved or released for selection to act upon. We now know we are interfering with both. It is a question of how we ought to interfere so as to do good and not do harm.

Most of the effects, good and bad, of any genetic policy can be felt only after the lapse of a generation. Moreover, the human breeding system is unique in its class basis, its elaborate discrimination, and its repugnance for outbreeding. Oppressed by closer fears, modern governments take less care for posterity than did their predecessors in antiquity. Governments which provide us with education have forgotten that only our parents can provide us with the ability to profit by it. There is indeed much evidence of a genetic component in the survival of nations. The nation which takes thought for its own genetical future is, therefore, most likely to have a future.

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NEWS and VIEWS

International Meteorological Organization Prize: Mr. E. Gold, C.B., F.R.S.

Mr. E. Gold, former deputy director of the Meteorological Office, has been awarded the International Meteorological Organization Prize for 1958 by the Executive Committee of the World Meteorological Organization, in recognition of his furtherance of the science of the atmosphere, his memorable contributions to the technology of weather forecasting, and his long and distinguished service to international collaboration in meteorology. The presentation was made by the president of the World Meteorological Organization, M. André Viaut, at the Royal Society's rooms on June 30.

Mr. Gold has been a leader in international meteorological work for many years, notably as president of the Synoptic Weather Commission of the International Meteorological Organization during 1919–47 and of the Meteorological Sub-Commission of the International Commission for Aeronautical Navigation during 1919–46. He also represented the Meteorological Office on three other Commissions of the International Meteorological Organization. The Synoptic Weather Commission, responsible for international uniformity in observing practice and for constructing the codes used for the international exchange of reports and forecasts, met on ten occasions and passed some 400 resolutions under Mr. Gold's presidency. This was a period of great increase in both the depth and breadth of meteorological practice as it was improved to use new knowledge of the atmosphere and to meet the requirements of users, notably aviators. In the more purely scientific field, Mr. Gold is well known for his pioneer investigation into the radiative equilibrium of the stratosphere, his work on the relation between barometric gradient and wind force, and his invention of the barometer correction slide and the visibility meter which bear his name.

The Prize consists of a gold medal bearing on one side the badge of the World Meteorological Organization and on the other the inscription: "*Societas Gentium Meteorologica. Pro singulari erga scientiam meteorologicam merito*", a diploma, and a sum of money. It is paid for from part of the interest on the balance of the funds of the International Meteorological Organization on the replacement of that organization by the World Meteorological Organization in 1950. The award is made annually by the Executive Committee from names proposed by member countries, and it is laid down that in the selection of the recipient both scientific eminence and the record of work in the field of international meteorological organizations are to be considered.

Mechanical Engineering at Liverpool: Prof. W. J. Kearton

Prof. W. J. Kearton, who is retiring from the Harrison chair of mechanical engineering in the University of Liverpool, served his apprenticeship in the Naval Construction Works of Vickers, Sons and Maxim at Barrow-in-Furness and was awarded in 1913 a Vickers scholarship to the University of Liverpool. After completing his studies at that University, he returned to Vickers, but in 1919 was appointed lecturer in mechanical engineering at Liverpool. He was promoted to a senior lectureship in 1937, a position which he occupied until 1947, when he succeeded Prof. G. E. Scholes as Harrison professor. While with Vickers, Kearton formed an attachment to heavy mechanical engineering which has remained one of his chief interests and to which he has made considerable contributions. His papers have been mostly concerned with steam-turbine design and he was at one time closely associated with the development of the mercury vapour–steam cycle. His books on steam turbines and on turbo-blowers and compressors are highly esteemed both by industrialists and by teachers of engineering, and his book on turbo-blowers has appeared in a German edition. During his long and distinguished career at Liverpool, Kearton never sought the limelight, but his qualities as an engineer and as a teacher have won the respect of colleagues and students alike. His students, in particular, have often paid tribute to the sympathetic and kindly help and guidance which he freely gave on so many occasions. He was chairman of the North-Western Branch of the Institution of Mechanical Engineers during 1948–50, and also served on the Council of the Institution during that period.

Prof. J. H. Horlock

Dr. J. H. Horlock, who has been appointed to succeed Prof. Kearton, was a scholar of St. John's College, Cambridge, during 1946–49 and took first-class honours in the Mechanical Sciences Tripos in 1949. He then joined the staff of Rolls Royce, where he spent two years on aero-engine design and development. In 1952 he returned to Cambridge to read for a Ph.D. degree, and joined the staff of the Engineering Department as a University demonstrator, being promoted to University lecturer in 1956. During 1954–57 he was a Research Fellow of St. John's College, and in 1956 went to the Massachusetts Institute of Technology for a year as a visiting assistant professor in the Mechanical Engineering Department. Dr. Horlock's research work has been connected with the fluid mechanics of turbomachinery and he has specialized on the theory of flow in compressors and turbines, making a number of contributions to the theory which have been published in the Aeronautical Research Council Reports and Memoranda series, and Current Papers. He published some experiments and theory on the secondary flow in pipe bends in the *Proceedings of the Royal Society* and he has also published papers on properties of steam and on the Field cycle. Dr. Horlock is at present engaged on a book on the fluid mechanics of axial flow compressors, which will be published shortly.

The Royal Society: Research Fellowships

The Committee representing the Royal Society and the University of Sheffield has appointed Mr. K. Dalziel as Sorby Research Fellow from October 1, to work in the Biochemistry Department of the University of Sheffield on biological kinetics. The Committee representing the Royal Society and the Armourers and Brasiers' Company has appointed Dr. T. E. Faber, of Corpus Christi College, Cambridge, as Armourers and Brasiers' Company Research Fellow from October 1, to work at the Cavendish Laboratory, Cambridge, on the electronic properties of liquid metals. Under the terms of the scheme to commemorate the late Lord Rutherford of Nelson, the Council of the Royal Society has appointed Dr. R. C.

Kumar, now working at the National Research Council of Canada, to be Rutherford Scholar for three years from next November, to carry out studies on elementary particles at University College, London.

Ciba Foundation Awards

An advisory panel of the Ciba Foundation has considered sixty-two papers from nineteen countries for the Ciba Foundation's Awards for 1958 for research relevant to the problems of ageing, and the following have received awards (the names of leading authors only are given): Dr. R. J. Boucek (Miami), Dr. D. S. McLaren (Mwanza, Tanganyika), Dr. A. Comfort (London), Dr. L. O. Pilgeram (Minneapolis), Dr. H. Sobel (Los Angeles), Dr. Z. Hruza jointly with Dr. E. Holečková (both of Prague), Dr. K. Walter (Giessen, Germany), Dr. A. A. Hürlimann (Bern), Dr. M. Murakami (Maebashi City, Japan). These awards are being offered for a fifth and final time in 1959, the closing date for entries being January 10, 1959, and further information may be obtained from the Ciba Foundation, London.

Darwin–Wallace Centenary

At a meeting of the Linnean Society on July 1, attended by members of the Darwin and Wallace families, representatives of other societies and institutions and members of the Linnean Society, the president, Dr. C. F. A. Pantin, unveiled a plaque in the meeting room commemorating the centenary of the reading before the Society on July 1, 1858, of the joint communication by Charles Darwin and Alfred Wallace on their theory of evolution by natural selection. At the meeting a hundred years ago neither Darwin nor Wallace was present: Darwin because of family bereavement and illness, and Wallace was still in Ternate. The papers were communicated by Sir Charles Lyell and Dr. (later Sir) J. D. Hooker, and as was the custom were read by the secretary. Hooker, writing to Francis Darwin at a later date giving an account of the meeting, said, "I was present . . . said something impressing the necessity of profound attention to the papers and their bearing on the future of Nat. Hist., etc., etc., but there was no semblance of discussion. The interest excited was intense, but the subject too novel and too ominous for the old School to enter the lists before armouring. It was talked over after the meeting, 'with bated breath'. . . ."

The papers were received by the secretary of the Society on the day before the meeting with a covering letter from Lyell and Hooker, and no prior notice of their title or contents was known to the Fellows before the meeting. They contained the first and quite independent statements of the great principle of natural selection. In both cases the discovery was the fruit of their profound experience of tropical nature while they were still young men. In further commemoration of this centenary the Society held a dinner in the Drapers' Hall on the evening of July 1, and on July 15, at a special meeting to be held at the Royal Geographical Society, some twenty Silver Darwin Medals will be presented to British and foreign biologists in recognition of their outstanding contributions to our knowledge of evolution.

Two Nuclear Reactors at the Atomic Weapons Research Establishment

HORACE, a zero energy reactor, is now operating at the Atomic Weapons Research Establishment at Aldermaston, Berkshire. It is being used for the study of the nuclear characteristics of a light-water research reactor, and consists of an arrangement of enriched reactor fuel in ordinary water. It will be used to investigate different types of reactor core arrangements and the use of different materials as 'reflectors' (to reflect neutrons back into the core). Work with it should enable the time taken for full commissioning of a second Weapons Group reactor of the same class to be materially shortened, since it will provide data relating to the control, safety and core arrangements of this type of reactor. This second reactor at Aldermaston, named HERALD, is being built by A. E. I.–John Thompson, Ltd., and should be completed by the autumn of this year. This will also have ordinary water as a moderator and coolant, will operate at power-levels up to five megawatts and will be used for research with neutrons and for the production of special isotopes. There are now thirty-five reactors either in operation or under construction in the United Kingdom for research, testing and power production.

Oak Ridge Research Reactor

A new research reactor at the U.S. Atomic Energy Commission's Oak Ridge National Laboratory has been successfully operated at its design power-level of 20,000 kW. of heat. The reactor, called the Oak Ridge Research Reactor (ORR), was brought to design power on May 29 after the power-level was raised in incremental steps over a period of several days while various operational tests were carried out. Operational testing is continuing. The reactor was designed to operate normally at 20,000 kilowatts, but may be operated at 30,000 kilowatts during some periods to meet the needs of the experimental programmes. The ORR will be used for fundamental research and engineering studies. The research programmes to be carried out in connexion with the reactor will include engineering studies on the effects of nuclear radiations, basic studies on the properties of metals, alloys and ceramics, and experiments involving neutron spectroscopy. The reactor also will be used for limited production of both short- and long-lived radioisotopes, many of greater specific activity than is now possible through other reactors available at the Laboratory. The ORR is a heterogeneous reactor, moderated and cooled with demineralized water. It has an average flux greater than 1×10^{14} neutrons per square centimetre per second, and has a beryllium-reflector core which utilizes fuel elements of uranium–aluminium alloy clad with aluminium.

Plutonium for Bombs

In the House of Commons on June 24, the Paymaster-General, Mr. R. Maudling, said that at the request of the Government, the Central Electricity Generating Board had agreed to a small modification in the design of Hinkley Point and of the next two stations in its programme so as to enable plutonium suitable for military purposes to be extracted should the need arise. The modifications would not in any way impair the efficiency of the stations, and as the initial capital cost and the additional operating costs would be borne by the Government, the price of electricity would not be affected. The country would thus be provided, at comparatively small cost, with an insurance against possible future defence requirements.

British Cotton Industry Research Association

In replying to a question in the House of Commons on June 24 as to whether he was satisfied that the British Cotton Industry Research Association was adequate to the present needs of the cotton industry, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, representing the Lord President of the Council, said that the Association provided an excellent example of progressive development and had achieved the confidence of the industry and a high international reputation. The Lord President had recently visited the Institute and was confident that the Council and Director of the Institute would continue to direct their programme of research effectively to those problems the solution of which would be of the greatest benefit to the cotton industry. Last year's grant to the Institute exceeded £84,000, and if the industry contributed more, the Government would increase its grant by £50 for every £100 extra from the industry.

Grants for Special Research

In reply to a question in the House of Commons on June 24, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, representing the Lord President of the Council, said that the Department of Scientific and Industrial Research was advised on grants for special researches by the Research Grants Committee of the Council, though the Committee may seek the advice of outside referees on any application. The chairman of the Committee is Prof. P. M. S. Blackett, and the chairman of the University Grants Committee and the Physical and Biological Secretaries of the Royal Society sit as assessors. Grants for nuclear physics this year amounted to £330,000 compared with £192,000 last year, and grants for other research has grown from £80,000 two years ago to £155,000 last year and to £320,000 this year.

Committee on Awards to Students

On June 25, the Minister of Education, Mr. Geoffrey Lloyd, in a written answer, announced that he and the Secretary of State for Scotland had decided to set up a Committee "to consider the present system of awards from public funds to students attending first degree courses at universities and comparable courses at other institutions and to make recommendations". The Committee would therefore consider the kind of awards to be made from public funds, the method of selecting students for such awards, and the principle of the hardship test required by the law as it now stands. Sir Colin Anderson has accepted the Government's invitation to act as chairman, and the other members of the Committee are: Mrs. Gladys Buxton, Mrs. Margaret Cooke, Mr. McL. Dewar, Miss J. A. Evans, Mr. W. W. Finlay, Mr. Norman Fisher, Alderman J. W. F. Hill, Mr. H. D. P. Lee, Dr. D. W. Logan, Mr. Ron Smith, Dr. L. S. Sutherland, Prof. Brinley Thomas, Dr. J. Topping, Mr. A. H. Wilson and Prof. E. M. Wright.

Research and Development in India

The third annual report and statement of accounts of the National Research Development Corporation of India, covering the year ended March 31, 1957 (pp. 17. New Delhi, 1957), records a steady expansion in activity. Seven new licences, including one development licence agreement, were negotiated and four new development projects involving an expenditure of Rs. 2.21 lakhs were sanctioned. A pilot plant was designed for de-ionization of cane juice, and experiments to determine the most suitable resins were expected to be complete by the end of the 1956–57 sugar season. Encouraging results were obtained in preliminary experiments on the production of copper chlorophyll from spinach leaves, and pilot-plant trials on the production of synthetic pine oil were conducted at the Shri Ram Institute for Industrial Research, Delhi. Encouraging preliminary reports have been received on the experimental infant food produced from buffalo milk at Kaira District Milk Producers' Union, Ltd., Anand, and a pilot-plant project for the production of phthalic anhydride by the fluidized-bed oxidation of coal-tar oil has been approved at an estimated cost of Rs. 2 lakhs.

Historical Documents

The library of the American Philosophical Society has acquired from time to time a number of interesting documents. Some of these are described in its *Proceedings* (**101**, No. 6; December 1957). The chapter on some newly obtained botanical papers is largely factual, but an illustrated account of sketches by T. R. Peale (1799–1885) is delightful. Another illustrated chapter deals with Augustin Dupré's sketches for medals, while yet another describes the so-called 'waggon affair' in which Benjamin Franklin took part in 1755. This "Wagon Broadside", the rarest of Franklin publications, was only acquired by the library last year. Another chapter describes a hoax on Dr. Franklin. The volume concludes with an account of Halliday Jackson's journal. Naturally, much of the material in this number is mainly of concern to Americans, but none the less there is much good reading of general interest to everyone.

A Hypothesis of Developmental Selection

From a study of lethal and semi-lethal mutants of the cruciferous plant *Arabidopsis thaliana*, J. Langridge has been able to advance a hypothesis of developmental selection (*Australian J. Biol. Sci.*, **11**, 58; 1958). Attention is directed to internal factors of selection and to barriers imposed by ontogenetic development as they may affect the degree of survival of newly arisen harmful mutations. The hypothesis states that "the survival of such mutant genes to the stage of germination depends on the diffusibility of the metabolite required by the mutants and the ontogenetic stage at which it is required. As a corollary of the hypothesis, those lethal mutants of flowering plants that appear after germination should, with certain predictable exceptions, have requirements for low molecular weight substances which may be supplied from external sources". In an experimental test of the hypothesis, the requirements for normal growth of eleven lethal or semi-lethal mutants were examined. The author reports that the six 'reparable' mutants require the following: (1) thiamine; (2) choline; (3) coconut milk; (4) sucrose or glucose; (5) a high osmotic pressure; (6) an alternation of temperatures for flowering. Of the five 'irreparable' mutants, (1) has decreased embryo growth; (2) lacks cotyledons; (3) lacks chlorophyll; (4) and (5) lack chloroplasts. The author considers that the behaviour of these mutants is generally in accord with the hypothesis.

Nitrogenous Components of Tracheal Sap

E. G. Bollard has investigated the composition of the nitrogen fraction of the tracheal sap in apples with the following results (*Austral. J. Biol. Sci.*, **10**, 279; 1957). Organic nitrogenous compounds accounted for most of the nitrogen present. Aspartic acid, asparagine and glutamine were quantitatively the most important compounds; glutamic acid and other amino-acids were also present as well as a peptide-like substance. While apple variety, root-stock or manurial treatment may have had effects on the level of nitrogen in tracheal sap, they seem to have had little effect on the proportions of the nitrogenous compounds present. Through the growing season, however, there was a definite change in the proportions of some of the constituents. The composition of the soluble nitrogen fraction of leaves and fruits showed distinct differences from the composition of tracheal sap.

Egg Rafts of Angler Fish

The common European angler fish, *Lophius*, lays its eggs in long mucoid rafts which float on the surface of the sea as ribbons 2-3 ft. wide and 25–30 ft. long. In all the related species of which anything is known of the breeding, similar rafts appear to be formed, always with scrolled ends characteristic for the species. This is true of the various batfish, frog-fish, goosefish and monkfish of American waters. In a recent paper (*Bull. Amer. Mus. Nat. Hist.*, **114**, 333; 1958) Miss P. Rasquin has described the structures which produce these egg rafts, the rafts themselves, and the embryology of two species, *Antennarius* and *Histrio*, from the Sargasso Sea. In these species the two ovaries are fused in the mid-dorsal line and form together a single tightly scrolled ribbon, with double curvature. There is a single lumen, while the germinal epithelium is only present on the inside surface of the scroll. Tufts project into the lumen, terminating in each branch, during the breeding season, in a ripening ovum. At the time of ovulation the whole epithelium lining the lumen secretes rapidly, during the course of a single day, a mass of mucoid material; then the ova are ovulated into this mass, coming to lie in the spaces in the mass formerly occupied by the tufts. Peristaltic movements of the ovarian wall force the mass out through the cloaca, centre first. There is a rapid intake of water through the pores which represent the spaces occupied in the ovary by the bases of the tufts. In the presence of a courting male the sperm is carried into the raft in this intake of water and fertilization takes place inside the raft. Each egg thus lies free in a separate compartment within the raft in communication with the outside sea-water. The raft itself is an enlarged replica of the internal surfaces of the ovarian lumen. Rafts can be produced with great rapidity, as many as twenty-five being produced in the course of a three-month breeding season. The early embryology as described in this paper seems very strange and requires further elucidation.

Contemporary Formation of Dolomite

One of the most intriguing problems of sedimentary geology is the mechanism by which the mineral dolomite (the double carbonate, $Ca.Mg(CO_3)_2$, as opposed to mixtures or solid solutions of calcium carbonate and magnesium carbonate) is formed in Nature. Dolomite has been an important rock-forming mineral, and with it there are often found types of fossils which suggest that it was formed in warm, shallow, marine waters. On the other hand, true dolomite has only been found in modern marine sediments in very minor quantities; also, attempts to synthesize the mineral in the laboratory at ordinary temperatures and pressures have so far been unsuccessful. Some fresh light has recently been shed on the problem by A. R. Alderman and H. C. W. Skinner, who describe, in the *American Journal of Science* (**255**, 561) of October 1957, sediments containing appreciable amounts of dolomite which are being formed to-day in saline lakes in the coastal region near Kingston, South Australia. The occurrence of dolomite in saltpans has been reported before; the particular significance of the present report is that it has been shown that the composition of the lake-water is essentially that of sea-water in various degrees of dilution and concentration, and that the precipitation of crystalline dolomite has been clearly related with elevation of *p*H at seasons when plant-growth is especially active. Similar deposits are said to be forming in the Coorong, an attenuated gulf linked to the sea at the mouth of the Murray River. The authors suggest that the region would repay a more intensive study.

Sulphur Dioxide in Atmospheric Chemistry

Sulphuric acid is a major destructive constituent of smoky fog. It has long been believed that it was produced by oxidation of sulphur dioxide in the atmosphere, but little evidence on the reality of the oxidation was available. The matter has now been clarified by experiments carried out by Chr. E. Junge and T. G. Ryan of the U.S. Air Force Cambridge Research Center, Bedford, Mass. (*Quart. J. Roy. Meteor. Soc.*, **84**, 46; 1958). They found that oxidation of sulphur dioxide can occur in dilute solutions in the presence of ammonia. Other substances, for example ferrous chloride, can also act as catalysts but are not found naturally in the atmosphere. The process stops after the *p*H value in the solution falls to about 2·2. Reference is also made to unpublished work by E. R. Gerhard showing that sulphur dioxide can be oxidized in the air to sulphur trioxide in strong sunlight without presence of water droplets and ammonia, but no general conclusion can yet be made as to the relative importance of the two processes.

Gairdner Foundation: International Awards

The Gairdner Charitable Foundation (Ontario), Canada, which was founded in 1957 and derived its funds from personal gifts of Mr. J. A. Gairdner, a Canadian industrialist and financier, and members of his family, has established two international awards, to be made for the first time in 1958: *The Gairdner Foundation Award of Merit*, a prize of 25,000 dollars to be awarded not more than once every four years to the individual or group of individuals who has made the most outstanding discovery or contribution in the fields of the arthritic, rheumatic and cardio-vascular diseases; and *The Gairdner Foundation Annual Awards*, comprising a series of prizes of 5,000 dollars each to be awarded in any one year to not more than five individuals who have made outstanding discoveries or contributions in the same field. Awards will be made at the discretion of the Foundation and will not be open to application on the part of potential

candidates. The purpose of these awards is to confer signal and substantial recognition upon individuals whose recent work constitutes tangible achievement in the fields of the arthritic, rheumatic and cardiovascular diseases. Winners will be free to make personal use of their prizes in any manner of their choice. Awards may be made without restriction as to nationality and will be payable in Canadian funds. Recipients who accept an invitation from the Foundation to participate in scientific meetings in Toronto or to visit professional colleagues at research or academic institutions in other countries and as a result incur travelling expenses may have the amount of their award increased appropriately.

Second International Conference for Analogue Computations

The Second International Conference for Analogue Computations will be held at Strasbourg during September 1–9. There will be four sections: theoretical, mathematical or physical problems; analogue computation materials; diverse and similar applications; connexion between analogue computers and arithmetical calculators. Further information can be obtained from M. F. H. Raymond, Secrétaire Délégué Général de l'Association Internationale pour le Calcul Analogique, c/o S.E.A., 138 Boulevard de Verdun, Courbevoie (Seine), France.

University News:

Leeds

The title of reader in civil engineering has been conferred upon Mr. E. Lightfoot. Dr. D. C. Munro has been appointed as lecturer in the Department of Inorganic and Structural Chemistry.

Liverpool

The following appointments have recently been made in the University of Liverpool: Dr. H. Edels, to be reader in electric power engineering; A. Young, to be senior lecturer in applied mathematics; Dr. J. C. Willmott, to be senior lecturer in physics; Dr. R. Huby, to be senior lecturer in theoretical physics; Dr. H. B. N. Hynes, to be senior lecturer in zoology; Dr. K. McCarthy and Dr. K. R. Dumbell, to be senior lecturers in bacteriology; Dr. J. L. Braithwaite and Dr. E. W. Macmillan, to be senior lecturers in anatomy; Dr. J. Glover and Dr. H. K. King, to be senior lecturers in biochemistry.

London

The following appointments have recently been made in the University of London: Mr. William Blackwood, pathologist at the National Hospital, Queen Square, to the University chair of neuropathology tenable at the Institute of Neurology; Dr. J. N. Cumings, clinical pathologist to the National Hospital, Queen Square, to the University chair of chemical pathology tenable at the Institute of Neurology.

Sheffield

The following appointments have been made: Dr. C. B. Wilby (lecturer in civil engineering); I. Fells (lecturer in fuel technology and chemical engineering).

Announcements

Prof. B. C. P. Jansen, lately director of the Nederlands Instituut voor Volksvoeding, has recently been made an honorary member of the Nutrition Society, in recognition of his distinguished contributions to nutritional science.

An exhibition on "Palæontology and Evolution", sponsored by the Palæontological Association in conjunction with the Geological Survey and Museum, will be opened at the Geological Museum, Exhibition Road, South Kensington, London, S.W.7, on July 9. The exhibition will remain open for several weeks, from 10 a.m. to 6 p.m. on weekdays and from 2.30 p.m. to 6 p.m. on Sundays.

The second Conference on Analytical Chemistry in Nuclear Reactor Technology will be held at Gatlinburg, Tennessee, during September 29–October 1. Further information can be obtained from C. D. Susano, Oak Ridge National Laboratory, P.O. Box Y, Oak Ridge, Tennessee.

The second Australasian Conference on Radiation Biology will be held at the Cancer Institute, Melbourne, Australia, during December 15–18. Papers on relevant subjects are invited, and titles and a 250-word abstract should be in the hands of the Convener by July 31. Registration forms and other information can be obtained from the Convener, Dr. J. H. Martin, Physics Department, Cancer Institute Board, 483 Lt. Lonsdale Street, Melbourne, Victoria, Australia.

A symposium on Microchemistry will be held at the University of Birmingham during August 20–27. It is organized by the Midlands Section and the Microchemistry Group of the Society for Analytical Chemistry, under the patronage of the International Union of Pure and Applied Chemistry. Further information can be obtained from W. T. Elwell, I.C.I. (Metals Division), Ltd., P.O. Box No. 216, Research Department, Kynock Works, Witton, Birmingham 6. Envelopes should be marked 'Symposium'.

An International Symposium on Atmospheric Diffusion and Air Pollution, sponsored jointly by the International Unions of Theoretical and Applied Mechanics and of Geodesy and Geophysics, will be held in Oxford during August 24–29. Participation is by invitation and some international unions and agencies will be represented by observers. The co-secretaries for the symposium are: Dr. F. N. Frenkiel, Applied Physics Laboratory, The Johns Hopkins University, Silver Spring, Maryland, and Prof. P. A. Sheppard, Department of Meteorology, Imperial College of Science and Technology, London, S.W.7, to whom any inquiries about the symposium should be addressed.

A symposium on Theoretical Organic Chemistry, arranged by the Chemical Society under the auspices of the Section of Organic Chemistry of the International Union of Pure and Applied Chemistry, will be held in London during September 15–17. The meeting commemorates the centenary of Kekulé's celebrated paper "On the Constitution and Metamorphoses of Chemical Compounds and on the Chemical Nature of Carbon" (*Annalen*, **106**, 129; 1858), in which Kekulé developed ideas which first came to him during his stay in London. The discussion will be arranged under three main headings, "Chemical Binding and Structure", "Nucleophilic Reactions" and "Electrophilic and Homolytic Reactions".

THE ROAD RESEARCH LABORATORY

OPEN DAYS

OPEN days were held at the Road Research Laboratory on May 15 and 16, when the work of the Materials and Construction Division at Harmondsworth and that of the Traffic and Safety Division at Langley were visited by some 2,000 highway engineers, manufacturers of contractors' plant, police, road-safety officials and others in a position to make use of the results of the Laboratory's investigations.

Among the exhibits were methods devised at the Laboratory for testing motor-cycle crash helmets for protecting the wearer against fracture of the skull or concussion, and for ensuring that the peak of the helmet is not so flexible that it will flap in a fast-moving airstream nor so stiff as to present a hazard in the event of a crash. The British Standards Institution uses these tests to maintain the high quality of helmets bearing the 'kite' mark. Another display showed the technique for investigating injuries due to 'crashes'. With the co-operation of the police forces in the areas of Slough, Windsor and Staines, a team from the Laboratory proceeds to the scene of each accident and collects data on the circumstances, and on damage to the vehicles and injuries to their occupants or to other road users. The data may include pairs of stereo-photographs from which an accurate record to scale of skid marks and other visible evidence of events immediately prior to a collision can be obtained with plotting equipment. The many photographs shown illustrated the importance of the failure of vehicle seats or fixtures in aggravating injuries sustained by occupants of a car, and the importance of a yielding rather than a rigid design of steering wheel and column if a driver is to escape serious chest injuries in a collision.

Another group of exhibits consisting simply of defective parts taken from cars was frightening in its implications on safety—it included a steering-wheel assembly in which the play was a quarter of the movement from lock to lock. During the open days, visitors were invited to have their cars tested by the Laboratory's equipment; a common defect found was misaligned headlamps. Of exhibits concerned with vehicles, that which attracted most attention was a short film showing how loss of control can occur when braking and how it can be overcome by using the Maxaret anti-skid device; this releases the pressure in the hydraulic braking system of any wheel of a car as soon as it begins to skid during emergency braking. The car in the film was braked heavily from 65 miles per hour and was manœuvred successfully around obstacles without loss of control. Another striking set of exhibits was a series of toughened glass windscreens which had been caused to crack into the characteristic mosaic by hitting them with a centre punch; a screen made a few years ago which had cracked into a mosaic of forty or more particles per square inch was difficult to see through, but one made to the present British Standard of twenty particles per square inch would provide a fairly clear view of the road ahead.

There were a number of exhibits illustrating the use of statistics (reported by the police and others) in revealing the importance of the various factors—road, vehicle and human—which affect the problem of accidents. For example, these statistics show that one type of accident to which young children are particularly prone could be reduced by fitting an ingenious safety device which consists of a strip of mirror fixed in front of the cab of a battery-driven electric vehicle of the type used for 'milk rounds'. A glance in the mirror before he moves off will enable the driver to detect the presence of a very small child playing on the road immediately in front of his vehicle.

Another group of exhibits was concerned with making roads and air-strips more resistant to skidding. This comprised a car equipped with a 'fifth wheel' for routine tests at normal speeds, a car and 'braking-force' trailer for testing wet airfield runways at speeds up to 100 miles per hour, and the Laboratory's portable 'skid-resistance' tester: this is a simple pendulum device under development for use by highway authorities for detecting slippery roads.

The Laboratory's apparatus for measuring the reflecting power of a road surface was also on show: this constant is needed by illuminating engineers in determining the capacity of the road surface to form the bright patches on which the lighting engineer relies for effective lighting of streets. Pedestrians are mainly seen in silhouette against the bright background of road surface and not by direct illumination.

The traffic exhibit was notable as showing the large amount of data on the way Great Britain's roads are handling traffic. Examples were included of apparatus now available commercially for use by highway authorities for recording the flow and speed of the traffic on their roads. A new feature was the inclusion of teleprinter devices for recording traffic speeds automatically.

A model road was used to illustrate the Laboratory's work in making road signs easier to read; it showed that for signs of the same area and cost, taking the distance at which the British-type sign with 4-in. letters could be read as unity, this distance was half as much again for the Continental 'map'-type sign with 5-in. letters and was doubled for the United States 'list'-type sign with 6-in. letters.

Several of the exhibits were concerned with the development of machinery in road construction; thus in one large hangar type of building covering a number of pits filled with different soils, measurements were in progress of the depth of the compacted layer and the density of compaction achieved by vibrating rollers and vibrating plate devices: this investigation is designed to supplement the information on soil compaction given in the Laboratory's text-book, "Soil Mechanics for Road Engineers". In another hangar, experiments were in progress with a machine which was pulverizing a heavy clay with an action resembling a milling cutter as it moved over it. The problem here was to shred the soil very finely so that it would mix satisfactorily with cement, the resulting 'soil cement' being compacted to give a road base of high bearing power. Another exhibit, dealing with the problem of laying a concrete road free from

undulations so that vehicles could ride over it very smoothly, used a working model to demonstrate the advantage of having a long wheel-base to the machine carrying the finishing screed.

In another exhibit samples of road-stones set in cement mortar and forming the tyre of a large wheel were being polished by the rubbing action of the tread of a smooth rubber tyre of another wheel, water and a fine abrasive being pumped on to the tyre. The degree of roughness remaining on the stones after polishing was then assessed in terms of the energy abstracted from a pendulum used to sweep a rubber pad over the samples of wetted stones. Use of this test would ensure that road-stones that polish easily are not used on sites, such as roundabouts on main roads, where it is desirable to maintain a high degree of resistance to skidding for safety in wet weather.

Another group of exhibits gave details of the Laboratory's full-scale road experiments concerned with 'pavement design', that is, the determination of the most economical type and thickness of road construction for use in a particular locality bearing in mind the road-stones and sands available, the bearing power of the subsoils over which the roads are built and the weight and intensity of the traffic to be met with; here a large-scale plan gave details of the 'step' experiment at Alconbury on road *A*1, where a two-mile stretch consists of sections of different road materials, each laid to a range of thicknesses. Instruments have been installed in each section and these record the pressures and deformations in the road structure and in the subsoil: from these and other studies it should be possible to assess the relative suitability of the various materials involved. In connexion with this type of experiment it is vital to know the weights of the different vehicles using the road; these are determined by a device which, for the purpose of the exhibition, was shown weighing the fast-moving traffic on the Colnbrook By-pass outside the Harmondsworth Laboratory. The device consists of a steel table, let flush into the road and carrying resistance strain gauges on the four legs: the system causes a spot of light to be deflected across a row of photo-sensitive elements actuating counters, the number of counters triggered off by each vehicle being a measure of the load. Another piece of work being done on this problem of 'pavement design' was exemplified by equipment adjacent to a test-track in the Laboratory grounds at Harmondsworth. Here a heavy vehicle was run over a group of sections of road of different compositions, and piezo-electric gauges in the underlying soil recorded the pressure exerted through each material, thus enabling its ability to spread the traffic loads to be determined.

Several exhibits were concerned with laboratory investigations. Thus a Thoma blood-count slide, modified to act as a micro-viscometer, was being used to determine the viscosity of the bitumen in the extreme surface layers of asphalts. This viscosity increases due to oxidation of the bitumen, but is decreased by the absorption of oil dropped from vehicles. To maintain a high resistance to skidding, an increased viscosity of the bitumen is desirable so that any bitumen in the surface is worn away by traffic so as to expose the sand or other fine aggregate texture.

One problem of immediate practical importance was concerned with determining the best surfacing for the roadway of the new Forth and Severn bridges. Trials on actual sections of the proposed bridge decks have suggested that 1½ in. of mastic asphalt sealed at the edges with rubber/bitumen will hold well to the steel decking and give long service under heavy traffic.

A pictorial display showed something of the work of the Colonial Section. T. Lonsdale

SCIENCE IN THE USE OF COAL

A CONFERENCE on "Science in the Use of Coal" was convened at the University of Sheffield during April 15–17 by the Institute of Fuel to provide an opportunity for coal scientists to discuss their work with industrialists. Each session began with an authoritative survey of work already published and an appreciation of current industrial problems.

Physics and Chemistry of Coal

In reviewing the properties of British coal seams, A. M. Wandless laid emphasis on the heterogeneity of coal and the great commercial importance of coals of low rank. In the second paper, L. Horton surveyed the chemical constitution of coal, with particular reference to oxidation, functional groups and solvent extraction. I. G. C. Dryden extended this discussion, referring, *inter alia*, to statistical structural analysis and physical structure. These valuable summaries not only provided a foundation for the subsequent proceedings, but also focused attention on what remains to be done and the most likely fields of application. For example, Dryden said that carbonization offers the most immediate application for coal science, while Wandless made clear that further work applicable to the use of small coal of low rank and on sulphur and other mineral constituents is particularly necessary.

During the session it became clear that there is now available sufficient information about the aromatic skeleton in coal and the nature of non-aromatic and oxygen groups to limit closely the possible views on the structure of coal. P. B. Hirsch interpreted the X-ray evidence for vitrains containing up to 90 per cent carbon in terms of ordered layers containing a few condensed aromatic rings, the layers being cross-linked to form larger units. This view conforms with the chemical evidence. P. H. Given and M. E. Peover provided evidence from controlled potential electrolysis for the presence of carbonyl groups conjugated with the ring system, previously suggested from consideration of the behaviour of the 1,600-cm.$^{-1}$ band in infra-red spectra. Attempts to reduce the aromatic systems led P. H. Given, V. Lupton and M. E. Peover to suggest that this process is resisted in coals of low rank owing to a high degree of cross-linkage. J. K. Brown *et al.* demonstrated by purely chemical means the presence of aliphatic groups, showing also that halogenation and nitration may prove efficient in introducing desired functional groups into coals. Photochemical studies by R. Bent and J. K. Brown

showed that solid coals are not photo-oxidized readily; but oxidation occurs when solutions of extracts of coal are irradiated by means of a mercury arc; similarly, chlorination of fine coal suspended in carbon tetrachloride also occurs. D. E. G. Austen and D. J. E. Ingram reported on the effect of carbonization and chemical treatment on the concentration of free radicals, concluding that the unpaired electrons are little influenced by the particular edge-groups present, but are closely associated with the aromatic skeleton.

P. J. Farenden and E. Pritchard reported a laboratory process giving good yields of highly fluorinated oils, without tar, in a single-stage reaction between coal of low rank at moderate temperatures and chlorine trifluoride. This empirical development may well find direct application in the fluorocarbon market.

N. Desai and S. J. Gregg showed that only when a compact swells as a result of sorption of vapours is it mechanically weakened thereby. From his studies of the sorption of methane by anthracite, A. S. Joy suggested for the latter a physical structure resembling that of a slightly elastic zeolite system.

These nine papers, since they represented current work only, did not cover the whole of present-day coal science; and physical structure had been covered at other recent conferences. It is a sign of the advances that have been made that the papers were followed by a lively and informed discussion, from which it was evident that the next few years will see a rapid clarification of what can, and what cannot, be done with coal.

Preparation and Breakage of Coal

In the second session, V. Fidleris and R. L. Whitmore described an electromagnetic method for measuring the falling speed of small foreign particles through stable suspensions, while G. F. Eveson and J. E. Gresham reported on the initial stages of a study of the factors governing the settling of floccules. The gap between these papers and the practical problems to which W. R. Chapman directed attention in his introductory survey was large, showing that the scientist's contribution to coal washing (in contrast to the maturity of fundamental studies) is only beginning. However, P. J. Beckett, A. D. Cummings and R. L. Whitmore showed the practical benefits that can accrue: their account of the disintegration of shales in water suggests that control of the *p*H of washery water might usefully reduce the slaking of shales. J. C. Macrae's data on the bulk density of crushed coal in relation to handling are applicable in carbonization, where charges of controlled bulk density are required.

The mathematics of breakage of coal is well advanced. I. Evans proposed a modification of Gaudin's law of size distribution in which account is taken of the dependence upon size of the probability of survival of the particles. T. G. Callcott extended the matrix representation of breakage processes to cover a second characteristic (such as ash content), showing that the selectivity or otherwise of a breakage process can be tested only by careful experiments. J. E. Ellis, W. D. Ray and J. Venables reported the experimental determination of a breakage matrix, which indicated the occurrence of interaction between particles differing in size. These papers provide a valuable tool for practical studies and show why much *ad hoc* work in the past has been inconclusive.

Carbonization of Coal

The ten papers that followed J. E. Davis's admirably compact survey of current knowledge gave ample testimony that science has made, and is now making, substantial contributions to this traditional use of coal. G. W. Fenton and A. H. V. Smith showed how petrological analysis assists in the selection of coals. J. J. Kipling and R. B. Wilson carbonized synthetic polymers and concluded that the properties of the carbon produced depend on the degree of cross-linking present in the original material or developed during its primary decomposition. Use of infra-red spectroscopy by A. L. Roberts, J. H. Towler and B. H. Holland in the analysis of carbonization gases showed the presence of a wide range of gaseous hydrocarbons and sulphur compounds, suggesting that these gases may be a potentially useful source of chemicals. Studying the chemical nature of coal-tar pitch, L. J. Wood and W. G. Wilman concluded that the largest molecules have branched chains of fused benzene and heterocyclic rings.

P. C. Finlayson and J. C. Macrae had made a preliminary study of the fluidity of a coal in the initial stages of thermal softening and suggested the presence of disk-shaped units in a solid/liquid system.

Another group of papers covered the cokes and chars produced by carbonization. J. G. O'Connor, M. W. Thring, C. Hulse and M. G. Perry showed that high volatile coal could be partially carbonized by a high rate of convective heating, lasting only one hour, to give a reactive and smokeless char, strong enough for the domestic market; the laboratory work was supported by studies at the pre-pilot stage and calculations for plant design. J. Owen described plant studies on the production of char in a fluidized bed. If these two processes should prove economical on further development, they could contribute to the availability of reactive smokeless fuels.

On the nature of cokes, A. D. Dainton and J. W. Phillips showed that cracking of briquettes is probably due to differential shrinking rather than evolution of gas and could be reduced by keeping the rate of heating below a critical value. M. S. Iyengar and R. S. Ghosh indicated that the strength of lignite briquettes is influenced by the presence of polar molecules and is increased by replacing much of the moisture by other polar compounds such as methyl alcohol or formic acid. A straightforward examination of the resistance of coke to breakage on impact led R. A. Mott to the important statement that it would be advantageous to use a smaller size of coke than is customary in blast furnaces.

Combustion and Gasification

In their introductory survey, R. H. Essenhigh and M. G. Perry directed attention to the relative importance of physical processes of diffusion and of rates of chemical reaction. This question is not fully resolved. D. B. Spalding described an ingenious model technique for studying the combustion of pulverized fuel. Then J. H. Burgoyne and V. D. Long reported some measurements of the burning (flame) velocity of suspensions of powdered coal in air, indicating, *inter alia*, a reduction in velocity when sodium chloride was added. R. H. Essenhigh and M. W. Thring measured the burning time of single particles of coal, relating it to the particle size and rank of the coal.

G. Underwood and M. W. Thring showed that over the temperature-range 650–850° C., coal smoke burns more readily than methane and unsaturated hydrocarbons. J. W. Hardcastle and M. W. Thring described apparatus for measuring luminous radiation from the flame over an over-feed coal bed and related it to the rate of feed of the coal and the percentage of secondary air. P. H. Crumley and W. McCamley discussed the behaviour of chlorine in coal during combustion, which is important in boiler firing, and suggested that the extent of vaporization of alkali is best related to the ratio of chlorine to ash-content.

The urgent need for further work was emphasized in the discussion, particularly in regard to the combustion of pulverized fuel.

Reactivity of Cokes and Chars

H. E. Blayden's survey of the kinetics of the reactivity of cokes and chars was supplemented by F. A. Burden's comparison of different methods of measurement. From analyses of the gases produced from pre-dried briquettes when burnt in air at a series of constant temperatures, D. R. Williams and J. A. Pudifoot proposed an index of chemical reactivity; comparisons with performance on open grates confirmed that (owing to the formation of surface oxide) the rate of loss of weight is not a sufficient measure of relative reactivity; but values of chemical reactivity at zero and at 1 per cent burn-off appeared to be well correlated with various practical characteristics of the fuels. L. J. Jolley and J. E. Stantan found that their measurements of reaction-rates of cokes with steam at 900° C. and with air at 475° C. were not correlated with specific surface areas of the cokes, suggesting the relevance of other factors such as ash constituents. Approaching the problem in a different way, F. D. Moles determined the minimum rate of burning at which a practicable bed of coke can be kept alight.

These papers and the discussion showed that there is still much to be learned about the physical and chemical factors determining the reactivity of coke, especially in regard to the relative importance of these, and other factors, in practice.

The discussions in each session added materially to the content of the papers. This is a sign that the number of established facts about coal now provides the scientist with a sure foundation for his work and will progressively simplify further work, although perhaps with coals of low rank new problems will arise. There is little doubt that the minerals associated with coal—only occasionally referred to at this conference—require much more consideration.

In every use of coal a diversity of mechanisms operates and the inter-relation between these is not yet on a quantitative basis. However, enough has been done to point the way and to show the potential benefit. When the investigations have proceeded further with a wide enough range of coals and associated minerals, the technologist also will have a sure foundation for his work. To achieve this end, the skills of every type of scientist and engineer must be blended. A philosophy of this most difficult field of industrial research emerged in some of the interchanges with industrialists, although the serious problem of communication, namely, the need for common language, was also evident.

The proceedings of the conference are to be published later this year.

R. L. Brown

THE EUROPEAN SEISMOLOGICAL COMMISSION

THE fourth general assembly of the European Seismological Commission was held in Utrecht during April 8–12, by invitation of the University and the Royal Netherlands Meteorological Institute, and with the support of Unesco.

The plenary meetings were held in the University building. The assembly was exceptionally well attended, there being fifty-nine representatives from twenty-four European and circum-Mediterranean countries in addition to several occasional visitors. The main discussions centred on the Earth's crust; seismological apparatus; the European earthquake catalogue; dynamical interpretation of earthquakes; and canalized waves in Europe.

After the session had been opened by the president, Prof. P. Caloi (Rome), the delegates were welcomed by Dr. C. J. Warners, director of the Royal Netherlands Meteorological Institute, on behalf of the Minister of Transport and Waterways, and by Mr. C. J. A. de Ranitz, burgomaster of Utrecht.

The outer layers of the Earth above the Mohorovičić discontinuity (usually called the crust) are now being studied extensively by means of great explosions. Such explosions have already been made in the French Alps during August and September 1956, in Germany and in the U.S.S.R. These investigations have shown that the Mohorovičić discontinuity is depressed under great mountains. Further experiments are being planned.

The catalogue of European earthquakes, to include instrumentally determined epicentres, depth of foci and initial times, as well as magnitude and macroseismic data, is being compiled, and a seismic map of Europe is being drawn. A general discussion was held on the definition and representation of seismicity, and on the determination of the 'magnitude' of an earthquake from macroseismic (non-instrumental) observations. It will be remembered that the 'magnitude' of an earthquake is now defined precisely in terms of instrumental data, and that this is different from the 'intensity' of the earthquake determined macroseismically. Recent earthquakes in many parts of Europe were also discussed as additions to the catalogue. It is envisaged, considering the progress already made with the seismic map of Europe, that the time will soon come when it will be fruitful for seismologists and geologists to meet again to discuss seismotectonic problems, and to attempt the construction of a seismotectonic map of Europe.

The construction of instruments for the better registration of earthquakes in general and for the recording of particular data in connexion with problems of the theory of elastic waves is being continued. A fruitful method has been, first, to construct a shaking table to simulate the earth-movements, and then to determine the response of the seismograph to the known movements of the

table. A great deal of ingenuity has gone into the construction of both tables and seismographs at Zurich, Stuttgart and elsewhere, and reports on the progress of the work, which is continuing, were given. For the general registration of earthquakes modern requirements are at least three components (north–south, east–west and vertical (Z)), and it was emphasized that for the study of particular waves it is preferable to have all three components giving identical response (that is to say, with the same frequency characteristics).

It would be invidious to attempt to assess the importance of the papers presented at the meetings, but perhaps summaries of two may be given.

The first, by Dr. R. Teisseyre, of the Geophysical Institute of the Polish Academy of Sciences, described the mechanism of earthquakes in terms of dislocation theory. The basic assumptions are the existence of the non-hydrostatic part of the stresses in the medium (Py 2) and the supposed distribution of the inhomogeneities (in the largest sense). This distribution includes some plane and its neighbourhood as the plane of active dislocation processes (slip plane, $y = 0$). It has been shown by Dr. R. Teisseyre and Sophia Droste that the inhomogeneities can be represented by the loop dislocations in the presence of the field Py 2. The loop dislocations increase under the influence of the field Py 2, and by interaction between themselves (synthesis of loops). The slip area increases. Finally, when the dislocation reaches the Earth's surface its energy is discharged. The calculated energy of discharge is in good agreement with observational data.

In the second paper, Dr. H. Berckhemer (Stuttgart) discussed the influence of the movement at the focus of an earthquake on the seismic wave spectrum. Dr. Berckhemer first stated his method of separating the influence of happenings at the focus from the influences of the wave-path and the seismograph on the wave spectrum. It appears that when the magnitude of an earthquake increases, the long-period wave spectrum is stimulated. Dr. Berckhemer explained this by theory and observation as being caused by extensive fault-breaks at the focus. His thesis is that it is possible to establish a connexion between the spread of the broken surface and the earthquake magnitude. This would make an important basis for the calculation of earthquake energy.

General impressions of the conference were, first, the intense interest of all present and the cut and thrust of very pointed discussion on all topics raised; secondly, the shift of emphasis on problems being tackled—for example, the present interest in very great explosions for seismological purposes and the return of 'La Géologie Sismologique' as introduced by the late Comte de Montessus de Ballore—and thirdly, the tendency to specialization within seismology.

It is expected that a second series of great explosions will take place during the summer of 1958 in the French Alps, and also that an explosion of 30–40 tons of explosive will be arranged to take place at a depth of some 300 metres in Belgium in September 1958. The elastic waves from these explosions will be recorded on seismograms and further knowledge obtained of the deeper structure of the Earth's crust. It is recommended that seismological stations obtain as soon as possible homogeneous sets of apparatus (recording three components having the same frequency characteristics) so as to be able to tackle seismological problems the more readily by direct comparison of the three components of vibration.

It is anticipated that the next meeting of the Commission will be held in Alicante during October 1959, when it is hoped that a symposium in collaboration with geologists will be held on seismotectonic problems, and another on the dynamical study of surface-wave problems.

The following were elected to office in the European Seismological Commission: *President*, Prof. P. Caloi (Rome); *Vice-Presidents*, Dr. J. Bonelli-Rubio (Madrid) and Prof. E. T. Savarensky (Moscow); *Secretary*, Mr. E. Peterschmitt (Strasbourg).

E. Tillotson

CLASSIFICATION OF BRACKISH AND INLAND SALINE WATERS

At the International Congress of Limnology in Helsinki in August 1956, problems of brackish water were discussed and, at the suggestion of Prof. S. Segerstråle, it was planned that a small group of specialists should be invited to attend a conference with the view of recommending a scheme of classification of brackish and inland saline waters which could be generally acceptable.

This conference was held during April 8–14 of this year at Venice under the joint auspices of the International Association of Limnology and the International Union of Biological Sciences. The place of meeting was the Centro di Studi Talassografici, the director of which, Prof. U. D'Ancona, is also president of the International Association. Papers were read by S. Segerstråle (Finland), A. Remane (Germany), B. Havinga (Holland), M. Băcescu (Roumania—*in absentia*), G. Petit and D. Schachter (France), U. D'Ancona (Italy), J. W. Hedgpeth (United States), L. C. Beadle (Uganda), H. Caspers (Germany), D. J. Rochford (Australia—*in absentia*), W. Schmitz (Germany) and E. Dahl (Sweden). The conference was also attended by J. Dill, M. Girard and P. Job (Food and Agriculture Organization, Rome), by T. T. Macan (secretary of the International Association of Limnology), and by some Italian biologists (A. Marcello, B. Battaglia, A. Vatova and A. Giordani Soika).

The papers were concerned with the history of the subject, and with the ecology of brackish waters in the Baltic, Elbe estuary, Black Sea, the lagoons of southern France and the Adriatic, some Australian estuaries and of intertidal zones of the Scandinavian coasts. Inland saline waters in the southern United States of America, Germany and in North and East Africa were also discussed, and the physiological mechanisms for adaptation to brackish and saline waters were reviewed.

The conference was very successful as a stimulating exchange of views and information on a subject, accounts of which have been very diffusely published and are thus difficult to collate.

At the final session a basic scheme was proposed for the classification of brackish waters which, in the opinion of the conference, would provide a useful framework of general application. It is based on zones of salinity of known biological significance and owes much to the earlier classifications of Redeke and Välikangas. Into this scheme more detailed sub-categories could be fitted to suit local conditions.

The proposed scheme is as follows:

Zone	Salinity-range (‰)
Hyperhaline	> ~ 40
Euhaline	~ 40 to ~ 30
Mixohaline	(~ 40) ~ 30 to ~ 0·5
Mixoeuhaline	> ~ 30 but less than adjacent euhaline sea
(Mixo)polyhaline	~ 30 to ~ 18
(Mixo)mesohaline	~ 18 to ~ 5
(Mixo)oligohaline	~ 5 to ~ 0·5
Limnetic (freshwater)	< ~ 0·5

For inland saline waters, it was agreed that no useful purpose could be served at present in devising a scheme of classification based on salinity zones. They are extremely variable in composition and several factors other than salinity are of great ecological significance. Moreover, our knowledge of them is as yet comparatively slight.

Venice is obviously a very suitable as well as delightful environment for a conference on this subject and, in spite of most unfavourable weather, excursions were made in and around the Venetian Lagoon. Here the technique of fish culture known as *vallicoltura* has been practised for many centuries and it involves some interesting problems in brackish water biology.

Through the generosity and hospitality of the Mayor of Venice, of the Venetian Tourist Association, of the Consorzio Vallicoltori, of Prof. D'Ancona and Prof. Alessandro Marcello, the members of the conference were able to enjoy much more than the biology of the Lagoon and were permitted to see many things of historic and artistic interest under expert guidance.

The proceedings of the conference will be published in Venice by the Centro di Studi Talassografici.

L. C. Beadle

THE CARNEGIE TRUST

THE fifty-sixth annual report* of the Carnegie Trust for the Universities of Scotland, covering the year 1956–57, includes the report of the Executive Committee with a summary of grants for the ninth quinquennium, October 1, 1952–September 30, 1957, the abstract of accounts for the year ended September 30, 1957, and the report upon the work of investigators, with lists of publications by scholars and recipients of grants and assisted papers. No new research scheme was introduced during the year, but those in operation have yielded satisfactory results. The block grants to universities to assist staff whose research involves travel are regarded as invaluable, and also the scheme enabling ten members of the staffs of universities to study abroad for up to twelve months, under which, in 1956–57, a geologist worked in Greenland, an archæologist in Asia Minor, a philologist in Ethiopia, a physiologist, zoologist, philosopher and surgeon in America, a biochemist and botanist in Canada and a historian in France. Assistance was given in the publication of seven manuscripts submitted by Scottish graduates or members of the staffs of Scottish universities. No fellowships were awarded, but, besides four senior scholarships, 36 scholarships were renewed and 23 awarded in June 1957. The Executive Committee is concerned to remove anomalies which have been created between Department of Scientific and Industrial Research grants and those obtainable from the Scottish Education Department on one hand and Carnegie Scholarships on the other. Repayments by former beneficiaries totalled £2,884.

The report upon the work of investigators under the research scheme during the year refers particularly to J. Y. Thomson's continued work on the numerical evaluation of the boundary layer flow past a flat plate placed lengthwise to the stream; A. V. Gold on the de Haas–van Alphen effect in conductors at high magnetic fields; Dennis Mackay on the interdiffusion of the ions Na^+, H^+ and Cl^-, and also water across an ion exchange membrane; Donald Mackay on the decomposition of the peroxides of the organic acids; and Iain M. T. Davidson on the dissociation of dibenzyl, in which he determined the kinetics of the decomposition and the bond-strength of the central C—C bond. A. E. Scott in his study of the acid-base and thermal racemization of the ketols has shown that the activation energy of the former is approximately half that of the latter. I. D. R. Stevens continued work on the addition of dinitrogen tetroxide and nitryl chloride to substituted olefines and on the effects of substituents adjacent to the double bond on *cis-* and *trans-* additions, while J. F. McKellar has identified the CHO, CH and OH radicals in the flash photolysis of acetaldehyde and formaldehyde both in absence and in presence of oxygen and is now studying the kinetics of their formation.

R. Logan has studied the influence of cytoplasm on the multiplication of ribonucleic and deoxyribonucleic acids in nuclear processes, using compounds labelled with carbon-14, and also the action of ultraviolet light and X-rays, using nuclei from normal and regenerating rat-liver cells and from calf thymus. M. Los's attempts to find a general synthetic route for the β-quinindines and the β-pyrindines failed, but gave some interesting new compounds. Janet Buchanan's work on the herbarium material on the genus *Luzula* in Kew and Edinburgh is nearing completion, and Isobel C. Gardner's work on nitrogen fixation in root nodules of non-leguminous plants has shown that the American *Myrica cerifora* can be inoculated from *M. gale* and that nitrogen fixation is carried on by nodules so induced. G. K. Wallace's work on visual responses in locusts is a useful contribution to our knowledge of locust behaviour. Beatrice M. Blance's work on the origin and development of the Iberian Bronze Age and Elizabeth Burley's study on the archæological evidence for Scottish–Irish connexions in the Dark Ages are specially commended.

* Carnegie Fund for the Universities of Scotland. Fifty-sixth Annual Report (for the year 1956–57) submitted by the Executive Committee to the Trustees on 24th February, 1958. Pp. iv+73. (Edinburgh: Carnegie Trust for the Universities of Scotland, 1958.)

VISUAL ORGANIZATION

By Dr. W. K. TAYLOR

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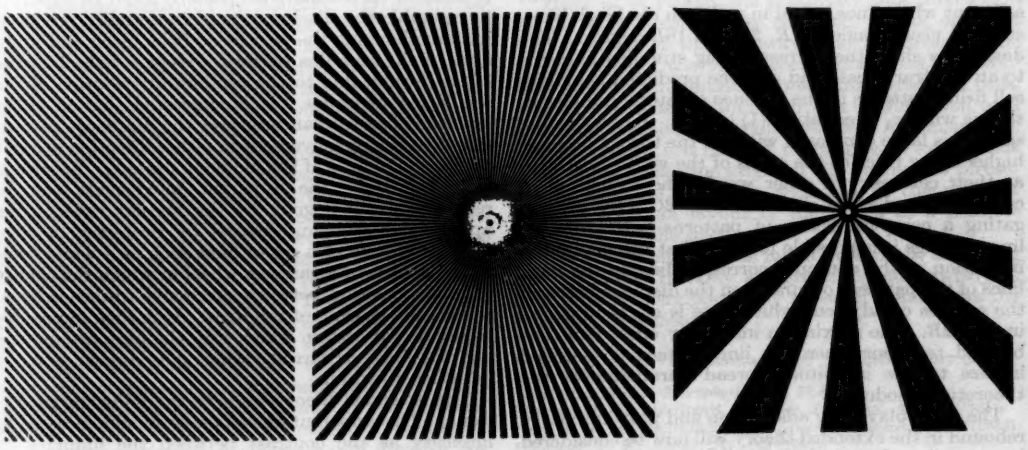
IN the functional theory of the mammalian retina which I proposed in 1955 [1], the discharge frequency of the ganglion cells in response to distribution of light intensity on the retina was represented by an equation of the form :

$$f(m,n) = c_1\, d(m,n) - c_2 \sum_R f(p,q) \qquad (1)$$

This equation was based on the physiological experiments of Kuffler[2] in which ganglion cells in the cat retina lying beneath a small spot of light were found to discharge nerve impulses at an increased rate in response to the illumination, whereas surrounding ganglion cells within a small distance of the spot were silenced.

In equation (1) the spread of this inhibitory influence is denoted by a radius R and the retina is assumed to be divided into a matrix of small squares. Within any small square situated at the junction of row m and column n the average frequency of ganglion cell discharge is denoted by $f(m,n)$. The constant c_1 represents the potential increase in ganglion cell frequency that would be caused by unit increase in the depolarization of the cell in the absence of inhibition, that is when c_2 is zero. The depolarization or driving function $d(m,n)$ is assumed to be the result, through photochemical action, of the average light intensity over square m,n, and it is suggested that a reduced and decaying value of this function also represents the driving signal of the ganglion cell during after-image phenomena. The constant c_2 represents the potential decrease in ganglion cell frequency that may be caused by unit change in the summated inhibition or hyperpolarization associated with the discharge of ganglion cells within a radius R of the square m,n.

Graham and Granit suggested in 1931 [3] that the lateral inhibitory signals could be carried by amacrine cells, but there is also a possibility that the inhibition may be transmitted between the rods and cones through horizontal cells. The theory, as formulated by equation (1), predicts responses to visual stimulus patterns that can be correlated with the visual phenomena of contour formation and simultaneous brightness contrast. There is, however, no component of output that can be related to the phenomenal movements in response to certain types of stationary stimulus patterns reported by observers in the experiments conducted by Erb and Dallenbach[4] and MacKay[5]. The earlier experimenters showed to a number of observers the Luckiesh–Moss[6] stimulus pattern (Fig. 1*a*), which consists of rows of equally spaced white lines on a black background. After a 1-min. presentation with adjacent white lines subtending a visual angle of 14·5′ all the observers reported having seen a "streaming movement" like "the drift of very fine snow" at right angles to the lines and proceeding in one direction or the other at various speeds from a slow drift to rapid streaming. The origin and explanation of this phenomenon are still unknown and the object of the present article is to suggest an explanation in terms of an extended form of my original theory[1] with two additional physiological features. These features are adaptation and post-inhibitory rebound, and since they take effect only after a period of fixation on a stimulus pattern their effects were neglected in the original



(*a*) (*b*) (*c*)

Fig.

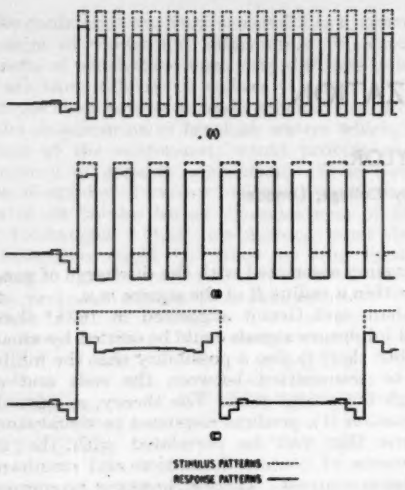


Fig. 2

theory, which was only intended to cover the initial response. The effects of eye movements during fixation are neglected in this theory since they are known to be small compared with the visual angles subtended by the relevant details of the patterns considered.

Adaptation and post-inhibitory rebound may be defined respectively as the decrease in firing frequency of a single excited ganglion cell with time when the stimulus is constant, and the burst of impulses generated by an inhibited cell when the inhibition is removed. Both effects can be seen in Kuffler's Fig. 8 (ref. 2).

The ganglion-cell firing pattern in response to the Luckiesh–Moss type of stimulus pattern predicted by the original theory is only similar in shape to the stimulus pattern if the line separation is of the same order of magnitude as, or less than, $2R$ when both are measured in terms of visual angle. This can be seen from Figs. 2*A*, *B* and *C*, in which the full lines respectively show cross-sections of the predicted firing pattern for parallel line stimulus patterns in which adjacent white lines, equal in width to the black lines, subtend visual angles of R, $2R$ and $16R$ degrees. The dash lines show the corresponding stimulus patterns to an arbitrary scale and also the predicted ganglion-cell firing patterns in the absence of lateral inhibition, that is when c_3 in equation (1) is zero. When the line spacing is large compared with $2R$ the theory predicts higher firing rates at the edges of the white lines than at their centres; in other words, the formation of contours or edges as shown in Fig. 2*C*. By investigating a complete series of patterns with different line spacings it is possible to show that the maximum inhibition of the neurones corresponding to the dark lines of the patterns occurs when the distance between the centres of adjacent white lines is equal to $2R$ as in Fig. 2*B*. The maximum inhibitory effect can thus be said to occur when the line pattern is matched in size to the inhibitory spread parameter of the theoretical model.

The parts played by adaptation and post-inhibitory rebound in the extended theory will now be considered by assuming that the stimulus pattern of Fig. 2*B* is fixated at time $t = 0$ on a part of the retina for which $2R$ is approximately equal to the separation of the white lines in the image, as required for matching. During the first fraction of a second the predicted response will be as shown in Fig. 2*B*, the activity in areas under the white lines inhibiting the activity under the black lines to a point well below the resting level corresponding to black except for the edge effect on the left. According to the extended theory, the neurones beneath the white lines begin to adapt and in doing so their inhibitory influence over the neurones beneath the black lines will be reduced until the latter eventually fire at higher rates according to the post-inhibitory rebound effect. In doing so they will inhibit the adapting neurones, thereby accelerating the reduction of their firing frequencies. If the magnitudes of these effects are sufficient, there is clearly a possibility that the rebounding neurones may become more active than the adapting neurones and it is suggested that this does in fact happen to a randomly distributed proportion of neurones during the apparent streaming-movement phenomena. A much larger rebound can be expected if the stimulus pattern is suddenly replaced by a plain surface since the adapting neurones will then lose the powerful drive by the white lines, this being replaced by the smaller after-discharge of the receptors.

In Kuffler's experiment the stimuli were spots of light for which equation 1 predicts a small inhibitory effect. With the parallel lines of Fig. 2*B* the predicted inhibition is much greater, and it is suggested that the rebound produced by this pattern can be large enough to cause appreciable inhibition of a proportion of neurones under the white lines or the neurones which were under the white lines if the pattern has been removed. The rebound is known to be transient, however, and when it decays the neurones under the white lines that have been transiently inhibited should tend to rebound and hence to restore the original pattern of activity. If the rebounds are sufficiently large the complete cycle may be repeated an unlimited number of times if the pattern is still present or a finite number of times at decreasing amplitude if the pattern is removed. The repeated cycles, assuming that they can occur, might be called rebound oscillations.

An optic nerve discharge pattern corresponding to a partial oscillatory after discharge following a period of fixation on the matched pattern could be expected to resemble the discharge pattern actually produced by interchanging the positions of the black and white lines of the stimulus pattern, except for the blurring of the former due to the random distribution of the oscillating neurones. It is suggested that in either case the observer can interpret the discharge pattern as a continuous movement in either direction at right angles to the lines of the inducing pattern. According to this theory the apparent movements can be regarded as analogous to the special case of the apparent movements created by projecting a cinematograph film of a set of lines such as a white fence or the spokes of a carriage wheel in which the change of image position between successive frames is equal to half the spacing of the lines. It is then impossible to decide for certain which way the lines are moving and the fence or carriage wheel may appear to move in either direction.

The extended theory leads to the following predictions. The apparent movements should increase in intensity as the contrast between the illumination of the white and black lines increases and as the width and separation of the lines are adjusted to match the inhibitory spread of the area of retina used for viewing

the lines. If the white lines are very narrow relative to the black their inhibitory effect will be small, and if they are too wide the inhibitory effect will be small. In either case the oscillation should be absent or short-lived and of low intensity. For a given ratio of widths the apparent movements would be most obvious when the line separation is of the same order as the width of the inhibitory field surrounding each element of retina.

Beitel's[7] curves for two-spot interaction indicate that the spread ranges from approximately 17′ visual angle in the central region to more than 2° in the periphery. It is therefore interesting to observe that the radial-lines stimulus pattern employed by MacKay[5] (Fig. 1*b*) was viewed at a distance of 1 metre and that at this distance the visual angle subtended by the centres of adjacent white lines at a radius of half the average distance from the centre to the edge of the pattern is also approximately 17′. It is obvious that with very small line spacing the pattern will not be resolved, but the theory predicts that the movements should also disappear for spacings that are large compared with 17′ in the foveal region or 2° in the periphery. With such wide lines the inhibition only extends a relatively short distance into the black region from the white boundary as shown in Fig. 2*C*, and the rebound can then only give rise to border or edge oscillations on the black–white boundaries. There is no apparent reason why the corresponding neural discharge pattern should give an illusion of continuous streaming movement since there is no tendency for the central parts of the black lines to give rebound impulses.

This prediction has been confirmed by experiments in which the stimulus pattern shown in Fig. 1*c* was employed. This pattern is based on Fig. 1*b* but the separation of the lines at any given radius is increased by a factor of eight to correspond with the eightfold increase in separation from Fig. 2*B* to Fig. 2*C*. In the experiments observers looked at enlargements of the patterns shown in Figs. 1*b* and 1*c* for 1 min. on different occasions but with the same illumination. Out of 30 observers tested, none reported having seen the circular streaming movement while viewing a 30 cm. × 40 cm. enlargement of Fig. 1*c* at 1 m., but all reported the effect with a similar presentation of the pattern employed by MacKay. The interpretation of this result in terms of the theory is that the inhibition within retinal areas beneath the central portions of the black areas of the image produced by Fig. 1*c* is insufficient to cause any appreciable rebound and that the illusion of a continuous smooth streaming movement is thereby lost.

In addition to the foregoing predictions concerning the magnitude of the movement phenomena the extended theory also predicts that the apparent velocity of the streaming movement with parallel line patterns or the angular velocity with radial line patterns, measured in lines crossed per second, should be equal to the frequency of the rebound oscillations measured in cycles per second. It is difficult to see how this could be tested experimentally since the nerve impulses generated by a single ganglion cell would have to be recorded and compared with the observer's estimate of the streaming velocity. It is possible to predict an upper bound to the velocity, however, since the highest frequency of oscillation could only be attained with one nerve impulse per cycle. The duration of an impulse is approximately one millisecond, and if the theory is correct it should be impossible to have an impression of a velocity in excess of 500 lines/sec. A velocity of 10 lines/sec. would seem more reasonable from Kuffler's recordings while my estimate of the velocity is approximately 30 lines/sec.

MacKay has suggested[5] that the moving visual images might occur in response to informational redundancy or regularity in the visual field. The present theory, however, predicts that although regularity is a necessary condition it is by no means sufficient, and that only a very restricted range of sizes and shapes of regular pattern should produce the phenomena. An example of a highly regular visual field that shows no sign of inducing the phenomena is a plain surface of any intensity for which the same signal is repeated at all points and which is therefore extremely rich in redundant information. More complex fields having the same degree of regularity may or may not give rise to apparent movements depending on the visual angle subtended by the elements. If, in particular, a circle is divided into $2n$ equal sectors which are alternately black and white ($n = 120$ for MacKay's pattern, Fig. 1*b*), the patterns so formed could be said to be equally regular irrespective of the value of the integer n. Since the streaming movement does not occur for plain surfaces it is evidence that for a fixed viewing distance it must disappear as n tends to infinity or zero. It appears when $n = 120$, but not when $n = 15$, and it is therefore apparent that the actual dimensions of the stimulus pattern image on the retina as well as the regularity of the pattern is an important factor, as predicted by the theory. The general criteria for the appearance of the streaming movement appear to be that there should be a number of equidistant lines separated by a visual angle that matches the inhibitory spread in the area of retina on which the lines are projected. It should be noted that, so far as a small element of area is concerned, radial, concentric or wavy lines that only change direction slightly within the area can be approximated by parallel lines within the area for the purpose of evaluating equation 1. The theory predicts oscillations and apparent movements for any pattern that gives an image of a sufficiently large number of roughly equidistant light and dark alternating lines of suitable separation and width on the retina.

There is, of course, the possibility that interaction of the type described by equation 1 may occur at higher levels of the pathway, and in particular the stellate cells of the visual cortex described by Sholl[8] may transmit inhibition between the pyramidal cells, just as the Renshaw interneurones of the spinal cord transmit inhibitory signals between motoneurones. Unfortunately, it is difficult to imagine an experiment that would locate the origin of the movement phenomena, but the available evidence at the moment appears to be in favour of the retina as a possible source, if not the only source.

The helpful suggestions made by Prof. J. Z. Young and Dr. J. A. B. Gray are gratefully acknowledged. The work was supported by research grants from the Nuffield Foundation.

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ACTIVATION OF HORMONAL SECRETIONS

Precorticotropin

In a number of communications from this laboratory[1–4], evidence has been published for the presence in certain anterior pituitary preparations of material which is ineffective in rapidly reducing the ascorbic acid content of the adrenal gland of the hypophysectomized rat when administered intravenously[5] (Sayers test), but which can elicit an increase in weight of the adrenal glands of the hypophysectomized rat when injected intraperitoneally over a period of some days (adrenal weight test). Other investigators have also found discrepancies between the results of the Sayers test and the adrenal weight test with different pituitary preparations (see Stack-Dunne and Young[6] for a review of these publications). Although the administration of growth hormone can bring about an increase in the weight of the adrenal glands of the hypophysectomized rat largely through stimulation of mitotic activity[7–11], it is most unlikely that growth hormone is the only substance in the crude pituitary extracts we have used[1,4] responsible for the increase in weight of the adrenals. We have used[1–4], among other pituitary preparations, a crude sterile alkaline extract of ox anterior pituitary prepared by a method described by Young[12] which contains little or no corticotropin as measured by the Sayers assay, but which is active in increasing adrenal weight. The virtual or complete absence from this crude ox pituitary extract of activity in the Sayers test was puzzling[13], particularly since fresh ox anterior pituitary tissue contains much corticotropin extractable by acid-acetone.

We have now found that our crude sterile alkaline extract of ox anterior pituitary (*FGS*), which is devoid of activity detectable in the Sayers test, acquires this activity after extraction with acid-acetone according to the method of Lyons[14]. However, this activity rapidly appears in the extract as its *p*H is brought to the acid side, maximum activity being attained at *p*H 3 (Table 1 and Fig. 1). Activity is obtained if the *p*H of the injected material is left at *p*H 3 or brought back to *p*H 8 immediately before injection, and whether or not any precipitate formed in adjusting the *p*H to 3 is spun off before the biological test is carried out. Furthermore, we have found that activity in the Sayers test also appears when the crude extract is treated with urea (3–8 *M*). It is convenient to refer to the material which gives rise to activity in the Sayers test as the result of these mild treatments as 'precorticotropin'.

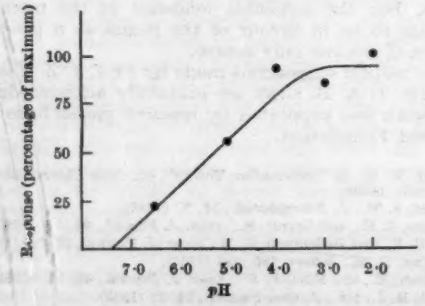

Fig. 1. Effect on the activity of *FGS* in the Sayers test of lowering the *p*H for approximately 30 min.

Table 1. Activity of a Crude Alkaline Ox Anterior Pituitary Extract (*FGS*) in the Sayers Test

Change in adrenal ascorbic acid content (μgm./100 mgm. adrenal) with:		
Untreated extract	Extract adjusted to *p*H 3	Extract treated with urea
+ 8 ± 5 (23)	− 55 ± 4 (31)	− 83 ± 8 (24)

0·25 ml. of extract injected/100 gm. body weight. The number of animals used in each test is given in parentheses

Table 2. Adrenal Weight-increasing Activity of Crude Alkaline Ox Pituitary Extract (*FGS*) before and after Adjustment of the *p*H to 3·0

Weight of the two adrenal glands of hypophysectomized rats:		
Control values (mgm.)	Values (mgm.) after 3 days treatment with: *FGS* untreated	*FGS* brought to *p*H 3·0
10·1 ± 0·5 (5)	16·6 ± 1·0 (4)	13·5 ± 1·0 (5)

0·25 ml./100 gm. body weight of extract injected daily for three days. The number of animals in each group is given in parentheses

When the *p*H of the crude extract (*FGS*) is brought to 3 by the addition of dilute hydrochloric acid, the adrenal weight-increasing activity tends to fall rather than rise (Table 2). In these tests the rats were hypophysectomized two weeks previously and were given three intraperitoneal injections of pituitary extract (or 0·9 per cent sodium chloride in control animals) for three days, the animals being killed on the fourth day.

These results have led us to ascertain whether our postulated precorticotropin is present in the supernatant fluid of a homogenate of ox anterior pituitary tissue prepared without adjustment of *p*H. The results in Table 3 were obtained with homogenates prepared in 0·9 per cent sodium chloride of such volume that 1 ml. of homogenate was equivalent to 20 mgm. of tissue. The homogenate was spun in the high-speed centrifuge (approximately 18,000*g*) and the supernatant fluid diluted 20–50-fold with 0·9 per cent sodium chloride for biological testing.

The supernatant fluid prepared from the homogenate exhibits no activity in the Sayers test until the *p*H is adjusted to *p*H 3, when a significant appearance of such activity takes place (Table 3). The addition of urea to make a 6 *M* solution has a similar activating effect.

A whole homogenate of ox anterior pituitary tissue prepared by us does possess Sayers test activity, as also does the residue spun out in the preparation of the homogenate supernatant. It appears, therefore, that in the ox pituitary glands as we collect them only a portion of the total potential Sayers-active material is present as precorticotropin.

We have found, in agreement with others, that a dilute solution of corticotropin is very unstable in slightly alkaline medium. Thus, of a solution initially containing 40 μgm./ml., all may be lost in 2 hr. at

Table 3. Activity of the Supernatant Fluid from an Ox Anterior Pituitary Tissue Homogenate in the Sayers Test

Change in adrenal ascorbic acid (μgm./100 mgm. adrenal weight)		
Supernatant diluted	Supernatant adjusted to *p*H 3·0 before dilution	Supernatant with 6 *M* urea before dilution
+ 11·5 ± 8 (17)	− 84 ± 8 (19)	− 61 ± 15 (4)

1 ml. of homogenate equivalent to 10 mgm. tissue; supernatant diluted 20–50 fold for biological test. The number of animals used in each test is given in parentheses

*p*H 7·4 at room temperature under the conditions of our experiments. It is very probable that any Sayers-active corticotropin initially present in our sterile crude alkaline pituitary extract will rapidly disappear. Nevertheless, since that extract may retain indefinitely its ability to acquire Sayers-test activity by suitable treatment, our precorticotropin appears to be stable in alkaline medium (*p*H 7–9).

Hall[15], Meites and Turner[16], and Carlisle[17] have all found little or no lactogenic activity, tested in rabbits, in crude anterior pituitary extracts, but have obtained from these crude extracts preparations of prolactin (luteotropin) which are highly lactogenic in their test animals. Carlisle[17] discusses the "artifactual nature of luteotropin" and writes: "it seems certain that luteotropin, as we know it in the extracted form, is an artifact which our methods of extraction have prepared from the inactive material of the primary extract. It is likely to be a different configuration of the same molecule, or of a fragment or multiple of it, for the only processes to which we have submitted it are unlikely to alter a protein to a greater extent than this". It should be noted that the galactopoietic activity of a crude ox pituitary extract (*FGS*) is very much greater than that of the prolactin which can be prepared from it[18], but growth hormone is largely responsible for this effect on milk secretion[19]. Dr. D. B. Carlisle has obtained results with corticotropin comparable with those he has seen with prolactin.

Since our precorticotropin is rendered active in the Sayers test by such mild treatments as adjustment of the *p*H of the solution to 3, or addition of urea (which might be expected to break hydrogen bonds) the change is unlikely to involve the fission of a covalent bond; that is, it is more likely to be a physical or a physico-chemical change than a chemical one. The nature of the change and its possible catalysis under biologically significant conditions, such as under the influence of enzymes, is under investigation. The question of the possible effect of our precorticotropin on the secretion of adrenal steroids also merits attention.

In the fresh homogenate of anterior pituitary tissue prepared by us, only a portion of the total corticotropin content is present as precorticotropin and is ineffective in the Sayers test. It is possible that the conditions of killing the animals from which the pituitary glands are obtained, or the time which elapses between the death of the animal and the preparation of the homogenate, may affect the proportion of the total corticotropin which may be obtained, in a form active in the Sayers test, in an alkaline extract. This is a subject for further investigation. What is clear at present is that the sterile crude alkaline extract of ox anterior pituitary tissue (*FGS*) which we have prepared and used in previous investigations[1–4] can possess no activity in the Sayers test but, nevertheless, can acquire such activity after mild treatment. That precorticotropin is itself responsible in part for the adrenal weight-increasing activity of crude anterior pituitary extracts is probable but not certain. It is, nevertheless, very likely that the presence of such precorticotropin in a crude alkaline extract of ox pituitary tissue accounts for the striking discrepancies between the results of tests for Sayers activity and for adrenal weight-increasing activity of such extracts, previously observed in this laboratory[1–4,6]. Moruzzi *et al.*[20] have described the presence in blood of two forms of corticotropin. One called 'active' corticotropin is a labile and ultrafilterable fraction found in the blood of normal subjects. The other, named 'activable' corticotropin, is detectable (by a Sayers type of test) only after treatment with oxycellulose. This form of corticotropin, according to Moruzzi *et al.*[20], occurs in the blood of human subjects with Addison's disease and other conditions in which adrenal function is deficient. More recently, Jailer *et al.*[21] have found activity in the adrenal weight test with plasma from patients with Cushing's syndrome due to bilateral adrenal hyperplasia and from pregnant women. No Sayers-test activity was found with plasma from the two patients with Cushing's syndrome whose plasma was tested in this respect. A relationship of these factors to our precorticotropin and also to that described by Golla and Reiss[22] in the serum of pregnant mares is possible but by no means certain.

One of us (P. R. D.) held a Colombo Plan Scholarship from the Government of India during the period that this work was carried out. The expenses of this investigation were partly defrayed from an expense grant from the Medical Research Council to one of us (F. G. Y.).

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A Crustacean Chromactivator

It is an old observation that colour change of Crustacea is brought about by the action of certain chromactivating substances, the best known of which are released into the blood by the sinus gland of the eye-stalk. In 1955, Knowles, Carlisle and Dupont-Raabe[1], working on *Leander serratus*, showed that the material stored in the sinus gland, substance *A*, was the precursor of three or more blood-borne substances, the α-substances, which themselves acted upon the chromatophores, while substance *A* was

never apparently released from the gland. The evidence suggested that the conversion of the large molecule of substance *A* into the smaller dialysable molecules of the α-substances was enzymatic. The sum of the activities of the α-substances was about equal to the activity of the parent substance *A*.

It has repeatedly been observed that the total chromactivity of an eye-stalk extract is increased twofold or more by boiling. But in this laboratory we have found that boiling an extract of a sinus gland does not affect the total activity (it does, however, prevent the conversion of the native substance *A* into the α-substances). A fresh extract of the remainder of the eye-stalk, after removal of the sinus gland, contains little or no chromactivity; but if such an extract is boiled, it gains an activity about equal to that of the sinus gland extract.

It is generally accepted that the greater part of the hormonal material found in the sinus gland is not actually produced there, but is first formed in the neurosecretory cells of the medulla terminalis ganglionic *X*-organ and of other ganglionic *X*-organs within the eyestalk. In fact, when boiled extracts are prepared from various fractions of the eyestalk, almost the total chromactivity is found in the sinus gland and the medulla terminalis ganglion *X*-organ. Unboiled extracts of the latter organ show no chromactivity. Electrophoretic examination of the boiled extracts of the organ reveal that they contain substance *A*, with no trace of the α-substances. When I dissected out the nerve connecting the organ with the sinus gland, I found that the proximal part, near the organ, yielded extracts which were inactive until boiled, while the distal part yielded extracts which were active when fresh. It is noteworthy that the staining reactions of the *X*-organ and sinus gland differ from one another, and that the proximal part of the connecting nerve tract stains like the *X*-organ while the distal part stains like the sinus gland. The substance present in the *X*-organ is apparently the precursor of substance *A*, and becomes converted into substance *A* during its passage along the nerve tract.

It is of interest to examine the range of treatments which will activate the inactive chromactivator of the *X*-organs. Besides boiling, this can be brought about by the action of acetone (especially if this is slightly acidified), alcohol, trichloracetic acid, formalin and urea. From this it would appear that it is sufficient to break hydrogen bonds to activate the material; the change involved is rather physicochemical than chemical.

The effect of mild treatment in activating a previously inactive storage substance is comparable to the observations I have previously made[3] upon the effect of similar agents in producing a prolactational or a corticotropic activity from inactive crude pituitary extracts. It may also be compared with the observations presented by Dasgupta and Young (preceding communication).

The earliest of the series of experiments on which this communication is based were noticed briefly by Knowles[2], who also reproduces a colour photograph taken in this Laboratory of the colour changes involved.

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RESPONSES OF THE ANTERIOR RETRACTOR MUSCLE OF THE BYSSUS OF *MYTILUS EDULIS*

In a recent study of muscle from *Mytilus edulis*, Hoyle and Lowy[1] have discussed the action of 5-hydroxytryptamine in producing relaxation of the tonically contracted anterior retractor muscle of the byssus. They comment on the fact that the muscle may fail to recover its ability to respond to d.c. stimulation by tonic contraction for several hours after exposure to 5-hydroxytryptamine; in some examples up to 40 hr. were required for recovery. They infer from this that 5-hydroxytryptamine is unlikely to be the substance normally responsible for relaxation in the intact animal (cf. Twarog[2]). The concentrations of 5-hydroxytryptamine used by Hoyle and Lowy were, however, of the order 1–10 μgm./ml. and it is of interest that relaxation can be obtained using concentrations as low as 10–0·5 mμgm./ml. This action is best shown when a tonic contraction has been induced by acetylcholine 1 μgm./ml. The effect of 5-hydroxytryptamine applied at the peak of contraction is to increase the initial rate of relaxation. Using concentrations as stated, repeatedly reproducible responses can be shown (Fig. 1).

As reported previously[3], this relaxing effect of 5-hydroxytryptamine can be demonstrated on a muscle in a state of tonic contraction induced by electrical stimulation alone, or by the combined effects of electrical stimulation and noradrenaline, or by the application of acetylcholine, the latter giving the most consistent results.

Fig. 1. Record of the isometric responses of the anterior retractor muscle of the byssus (contraction downwards). Contraction induced by acetylcholine (1 μgm./ml.) and alternate records show the relaxation under sea water control and following 5-hydroxytryptamine (10 mμgm./ml.). Inset, diagram showing the time of application of the drugs. Dotted line (*c*) indicates the course of control relaxation

Hoyle and Lowy state further that since the anterior retractor muscle of the byssus is unable to destroy 5-hydroxytryptamine the effects produced by the drug are of pharmacological interest only. Blaschko[4] has reported the presence of amine oxidase in the muscle. That amine oxidase is an enzyme capable of destroying 5-hydroxytryptamine is now well known.

Although the findings reported above do not serve to prove that 5-hydroxytryptamine is the naturally

occurring relaxant in this species we feel that such a role should not be excluded solely on the results of experiments using very large concentrations of the drug.

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Recently, Evans and Schild[1] have examined the effects of electrical stimulation and drugs on vertebrate smooth muscle which had been depolarized by the external application of potassium ions. The conducted response to electrical stimulation was abolished under these conditions but the contraction in response to drugs, presumed to be due to local excitation of smooth muscle cells, was maintained. Experiments on invertebrate smooth muscle, the anterior retractor muscle of the byssus of *Mytilus edulis*, have given results which differ from these. This muscle can be depolarized by exposure to 0·56 *M* potassium chloride and this produces, under isometric conditions, a prompt development of tension which is maximal in about 10 sec., and relaxation occurs over a period of 30–40 sec. The muscle is then inexcitable by electrical stimulation (either d.c. which normally produces a tonic contraction or 2-m.sec. pulses 4/sec. which normally produce a phasic contraction), and it also fails to respond to acetylcholine in concentrations up to 2 μgm./ml. The course of depolarization of the muscle by potassium chloride was determined by Twarog[2], who found the maximum potential on depolarization was obtained 20–25 min. after the potassium chloride contraction, and in the experiments reported above the responses to electrical stimulation and drugs were examined within this period. Soaking in sea water restored the excitability to electrical stimulation and to drugs.

Owen[3] reported that lamellibranchs could be narcotized and caused to relax by exposure to propylene glycol monophenyl ether ('Propylene phenoxetol'), and preliminary experiments indicate that the anterior retractor muscle of the byssus may be rendered insensitive to electrical stimulation and to acetylcholine by soaking in a 0·25 per cent solution of this compound in sea water. Furthermore the contraction produced by 0·56 *M* potassium chloride is abolished under these conditions; the effect of phenoxetol is reversible on soaking the muscle in sea water.

A further agent which may be of value in differentiating the mode of action of drugs and electrical stimulation on the membrane is the toxin from *Gymnodinium veneficum*[4] which is presumed to render nerve and muscle, including the anterior retractor muscle of the byssus, inexcitable by increasing the permeability of the membrane to sodium ions. So far, experiments I have made with the impure toxin have not yielded clear-cut results, a marked change in threshold occurring rather than an absolute failure of response to stimulation.

Details of this investigation, including the effects of other ions on the response of the muscle to drugs, will be reported elsewhere.

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ACTION OF HYDROCORTISONE ON RESPIRATION OF HUMAN CANCER CELLS IN TISSUE CULTURE

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A primary human epidermoid cancer of the larynx, *H.Ep.*2(Toolan), was transplanted into X-irradiated and cortisone-treated rats[1], and, after two generations in rats, has been grown in tissue culture since September 1952[2]. The tissue culture cells when re-implanted into an irradiated, cortisone-treated rat form a typical epidermoid cancer. In tissue culture these cells, growing on the glass surface of *T*-60 flasks[3], form dense epithelial sheets very much like the original epidermoid cancer. Their rate of growth is relatively high, and their number doubles in about three days[2]. In the following experiments the culture medium consisted of 10 per cent of half-diluted embryo extract, 40 per cent horse serum, and 50 per cent Earle's balanced salt solution containing 0·22 per cent sodium bicarbonate and phenol red as *p*H indicator. Cultures of several flasks were thoroughly scraped from the glass surface, the cell suspensions pooled, and 5 ml. were put in each of four *T*-60 flasks. 0·5 ml. of the pooled cell suspension was used for enumeration of cell nuclei in the hæmocytometer[5], after trypsinization. Except for enumeration of cell nuclei, no trypsinization was used. Approximately equal distribution of cells in the four *T*-60 flasks was achieved by continuous mixing of the stock suspension with a pipette. 5 ml. of fresh medium were then added to each of the four flasks, and to two of them hydrocortisone in a final concentration of 0·62–1·25 γ per ml. Since the hydrocortisone stock solution contained 50 per cent ethanol, ethanol in the same dilution was added to the control flasks. Hydrocortisone was added to the cultures 3–4 times at intervals of about three days, and also to the Warburg vessels before they were attached to the manometers.

The medium of the four *T*-60 flasks was completely removed with a Pasteur pipette, and to each flask 3 ml. of fresh medium were added. The cells of the

Table 1. Human Cancer growing in Cortisone-treated Rats and in Tissue Culture

Exp.	Q_{O_2} (10^{-5} µl. O_2/hr./cell)		$Q_{CO_2}^{O_2}$ (10^{-5} µl. CO_2/hr./cell)	
	Control	Hydrocortisone	Control	Hydrocortisone
		Strain *H.Ep.* 2		
1	− 0·23	− 0·33	0·85	1·0
2	− 0·35	− 0·55	0·85	1·25
3	− 0·30	− 0·50	0·40	0·70
4	− 0·43	− 0·85	0·95	1·10
Average	− 0·33	− 0·56	0·76	1·0
		Strain *L*		
1	− 0·66	− 1·0	0·50	0·80
2	− 0·80	− 1·40	0·60	0·90
3	− 0·50	− 0·80	0·30	0·60
4	− 0·87	− 1·46	0·44	1·46
Average	− 0·71	− 1·14	0·46	0·94

two hydrocortisone-treated *T*-60 flasks were thoroughly scraped from the glass surface and the 6 ml. of cell suspension pooled in a large tube. The cultures of the two control flasks were treated in a similar manner. 3 ml. of the hydrocortisone pre-treated cell suspension were put in a Warburg vessel, the centre well of which contained 0·2 ml. of 15 per cent potassium hydroxide, for measurement of oxygen uptake, and the remaining 3 ml. of the cell suspension were put in a Warburg vessel with 0·2 ml. saline in the centre well for measurement of carbon dioxide evolved. The pooled 6 ml. of cell suspension from the control *T*-60 flasks was equally divided and put in two Warburg vessels, one for the measurement of oxygen consumption and one for measurement of carbon dioxide production. 0·5 ml. of Earle's saline containing hydrocortisone was added to each of the two Warburg vessels containing the cell suspensions pretreated with hydrocortisone, and 0·5 ml. of Earle's saline without hydrocortisone was added to each of the control vessels.

Measurements of respiration and aerobic glycolysis of strain *L* cells derived from a fibroblast of normal subcutaneous tissue of the mouse were carried out in the same way, and the results compared with those obtained from human cancer cells of the larynx. Strain *L* was producing tumours in 1942 in 68 per cent, but in 1946 the incidence of sarcomas produced by strain *L* dropped to 1 per cent. Strain *L* has been carried in this laboratory since 1954. Growth-rate of both strain *H.Ep.*2 and strain *L* was estimated by nuclear counts. Inocula of about equal size were put into six flasks and on three consecutive days nuclear counts of two flasks were carried out.

In Table 1 the rates of respiration and of carbon dioxide production are compared with those of strain *L*. The Q_{O_2} and $Q_{CO_2}^{O_2}$ represent average values obtained over a period of 3 hr. With the strain *L* line, respiration is 100 per cent higher than with cancer cells. This applies to cells treated with hydrocortisone as well as to the control cultures. In control cultures, aerobic glycolysis is 67 per cent higher in cancer cells than in the strain *L* fibroblasts. In hydrocortisone-treated cultures, aerobic glycolysis is only 6 per cent higher in cancer cells than in strain *L* fibroblasts.

It is noteworthy that the ratio of aerobic glycolysis to respiration in strain *L* fibroblasts is 0·64 (46 : 71), while in human cancer cells the ratio is 2·3 (76 : 33).

With regard to the effects of hydrocortisone, aerobic glycolysis was more than doubled with strain *L* cells and increased only by 33 per cent with the human cancer cells. Hydrocortisone increased respiration in the two cell strains by 66 and 57 per cent respectively.

The ratio of aerobic glycolysis to respiration was increased by hydrocortisone from 0·64 to 0·81 with strain *L* cells and was decreased from 2·3 to 1·8 with the human cancer cells (Table 1).

Figs. 1 and 2 depict the respiration and carbon dioxide production of the human cancer and strain *L* cells, with and without hydrocortisone over a period of 4 hr. It is evident that the effects of hydrocortisone are consistent throughout the period of observation.

Fig. 3 shows the comparative rates of growth of the two cell types in tissue culture.

Respiration and glycolysis of fibroblasts in tissue culture have been studied by a number of investigators[6–19]. Most authors have found high anaerobic as well as aerobic glycolysis and a rather low ratio of aerobic glycolysis to respiration. Some, however, have reported that the ratio of aerobic glycolysis to respiration is as high in normal tissue cultures as in

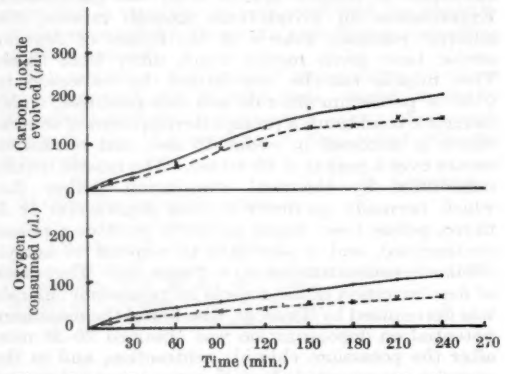

Fig. 1. Respiration and glycolysis of human cancer cells. Average of four experiments. ——, with hydrocortisone; – – –, control

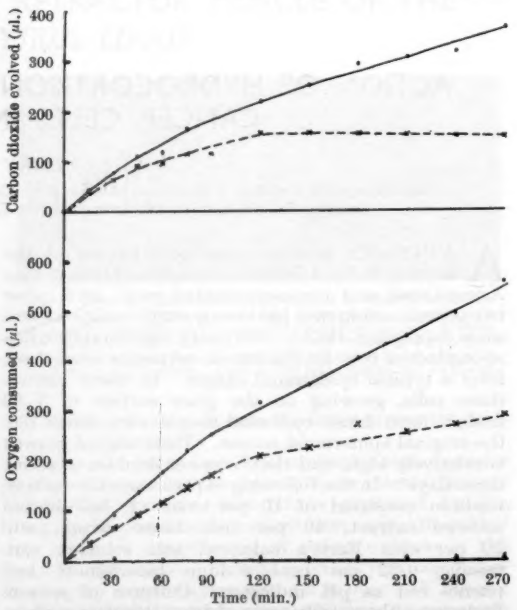

Fig. 2. Respiration and glycolysis of strain *L* cells. Average of four experiments. ——, with hydrocortisone; – – –, control

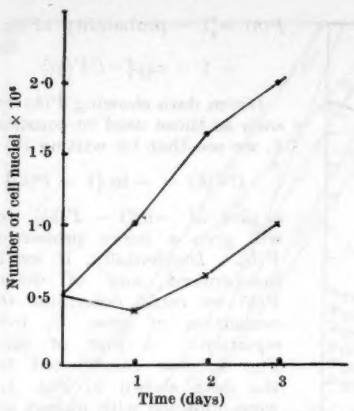

Fig. 3. Comparative rates of growth of two cell types in tissue culture. Top, strain *L*; bottom, *H.Ep.*2

malignant tumours[15]. The present results show a fairly high aerobic glycolysis of strain *L*, but a low ratio of aerobic glycolysis to respiration.

Early investigators postulated a fundamental relationship between glycolysis and growth, and even a dependence of growth on glycolysis. (The decline of growth with the age of the embryo was at one time related to the decline of the intensity of glycolysis.) In later work any fundamental relationship between growth and glycolysis has been denied[16,17]. The present results likewise demonstrate that high glycolysis in tissue culture is not related to rapid growth. The high aerobic glycolysis of cancer cells in tissue culture is not associated with a higher rate of growth, for the cancer cells in the present study actually grow at a rate considerably less than that of the strain *L* (Fig. 3). The high aerobic glycolysis of *H.Ep.*2 cells appears thus to be due to a specific feature of malignancy, but may be here in part secondary in nature, resulting from a depression of respiration.

It has been reported[18] that 2,4-dinitrophenol stimulates the respiration of both malignant and non-malignant cells, and that under the influence of dinitrophenol the respiration of the malignant cells approaches that of normal cells. This was considered as inconsistent with the theory of irreversibility of the respiratory defect of cancer cells.

In the present studies hydrocortisone increased the respiration of human cancer cells and of strain *L* cells to a similar degree. Thus even the improved respiration of human cancer cells remains well below that of strain *L*.

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THE IMPACT TESTING OF EXPLOSIVES

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FOR many years the sensitivity of explosives has been measured by one form or another of impact test. This test is usually arranged so that a weight is dropped, from a series of heights, on many individual samples of the explosive under study, to determine whether or not each sample explodes. The range of height is chosen, by trial and error, so that the lowest height rarely, and the greatest height almost always, initiates an explosion. In this way one obtains a curve showing percentage initiation (fractional fires) as a function of drop-height. Powdered explosive is almost always used. The sample struck by the falling weight may be heaped in a conical pile upon a flat surface, or confined to varying degrees in a metal or plastic container. When the sample is completely contained, the impact of the falling weight is transmitted through the container wall either by compression or shearing through it. In some tests the falling weight strikes the exposed or confined explosive directly, and in this case the weight is usually a metal sphere. Often the energy of the weight is transmitted to the powder or its container by striking a flat, rounded or pointed pin. Here we employ data obtained with the Picatinny Arsenal impact machine, which is a typical version of these devices. In this machine the powder is contained in a shallow dish-like indentation cut in one end of a flat steel cylinder. A controlled amount of sample, filling the hollow, is confined by a thin brass cap which is pressed over the indentation. A flat steel disk with a slot cut along one diameter is placed, slot side down, directly in the centre of the brass cap over the powder. The falling weight then strikes this cylindrical pin, which transmits the energy of impact to the container and its powder.

When one attempts to use a curve of percentage fires against drop-height, obtained with any of these machines, to derive information about the explosive properties of the samples being tested, one is faced by what appear to be very complex analyses. Two examples of the kind of information one would like to obtain from these analyses are: How is the impact energy divided between sample and container, and what is the maximum instantaneous temperature reached by any part of the explosive? Even with

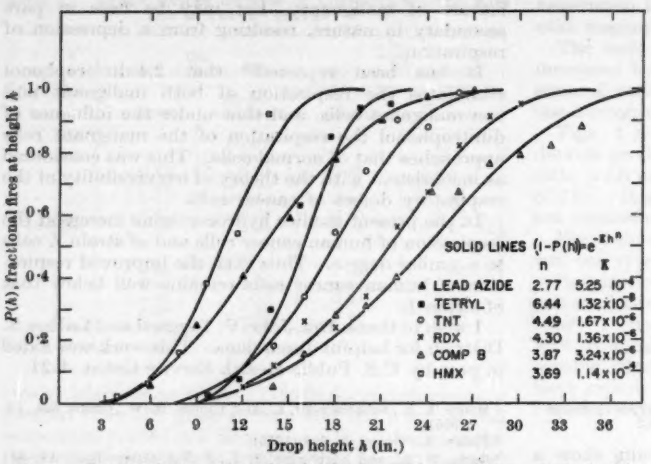

Fig. 1. Fractional fires versus drop-height for various explosives obtained with a Picatinny Arsenal-type machine. The equation $\{1 - P(h)\} = \exp(-Kh^n)$ has been fitted to the data using the constants tabulated

the simplest impact machines, in which the powder is compressed between flat plates, calculation of any mechanical property of the explosive under impact is practically impossible. However, an equation may be derived from which one may obtain information about some of the properties of the explosive under study, and in addition, information on the mechanical properties of the impact machine. This equation will be derived for an explicit set of assumptions, but it must be emphasized that the same result may be obtained with similar but different assumptions.

First, consider that in an impact machine the energy imparted to the explosive is a function of drop-height. Also, assume that the explosion will be initiated if energy in excess of a fixed critical amount is imparted to a region of the powder, or a region of a crystal in the powder, that contains at least one 'site' possessing the requisite properties for initiating the detonation. These sites may be, for example, hot spots[1], bubbles, crystals in the correct juxtaposition to detonate when pushed together, or some crystalline or molecular arrangement the relation of which to detonation is not yet understood. Let the volume of explosive energized in excess of the critical energy necessary to activate a site, by a weight falling from height h, be $V(h)$, where h is in inches. Assume that the density of sites, C per unit volume, is small and that they occur at random so that they are distributed according to Poisson statistics among the numerous crystallites. A detonation will occur if the volume $V(h)$ contains at least one site; likewise, a detonation will not occur if $V(h)$ is devoid of sites. From Poisson statistics the probability that the volume $V(h)$ contains *no* sites is $\exp\{-CV(h)\}$. Let the probability that a drop from height h produces a fire be $P(h)$. (Actually $P(h)$ will be the fraction of fires occurring for height h.) Then:

$$P(h) = \begin{matrix}\text{probability of no} \\ \text{fires}\end{matrix} \quad (1)$$
$$= 1 - \exp\{-CV(h)\}$$

Given data showing $P(h)$ versus h, such as those used to construct Fig. 1, we see that by writing (1) as

$$CV(h) = -\ln\{1 - P(h)\} \quad (2)$$

a plot of $-\ln\{1 - P(h)\}$ versus h will give a curve proportional to $V(h)$. Incidentally, if we had an independent way of determining $V(h)$ we could determine the concentration of sites, C, from this equation. A plot of this type, Fig. 2, was constructed from all the data shown in Fig. 1, which were obtained with impact machines of the Picatinny Arsenal type, and from one additional set of data, the points shown for copper chlorotetrazole. These additional points, obtained with a machine in which the explosive is pressed into an open cylinder and the impact of the falling ball is transmitted to the explosive with a pointed pin that is in contact with it, are included to indicate that the $V(h)$ functions for the two machines are somewhat different. The lead azide data are from unpublished work by J. E. Abel, R. W. Dreyfus, J. V. R. Kaufman and P. W. Levy. The results for copper chlorotetrazole were obtained especially for this article by A. Forsyth. All other data are from A. Bullfinch, Picatinny Arsenal Technical Report 2282 (unpublished).

The points obtained with the Picatinny Arsenal machine suggest that the function $V(h)$ is the same for all the materials listed and has the form kh^n. Considering the complex nature of the explosive container, this is a reasonable expression. Putting $V(h) = kh^n$ into (1) we obtain:

$$P(h) = 1 - \exp(-Ckh^n) = 1 - \exp(-Kh^n) \quad (3)$$

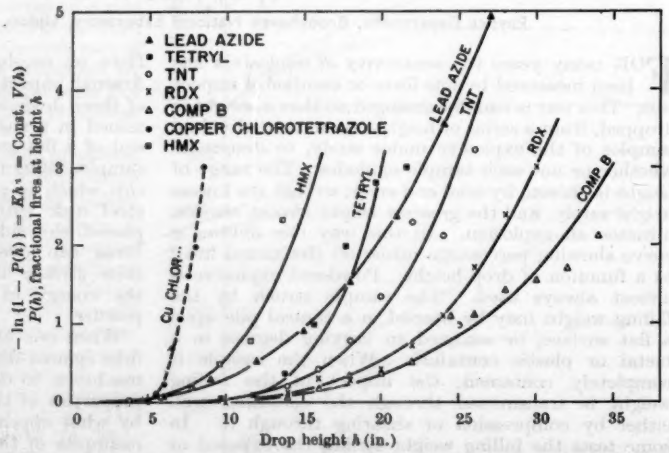

Fig. 2. The $V(h)$ function, which can be determined to within a scale factor from impact data, for results obtained with the Picatinny Arsenal-type impact machine, with one curve (copper chlorotetrazole) for a different type of impact machine; the $V(h)$ functions for the two machines are somewhat different. For the Picatinny Arsenal-type machine $CV(h)$ is of the form: const. $\times kh^n = Kh^n$. The solid lines represent this expression computed with the constants shown on Fig. 1

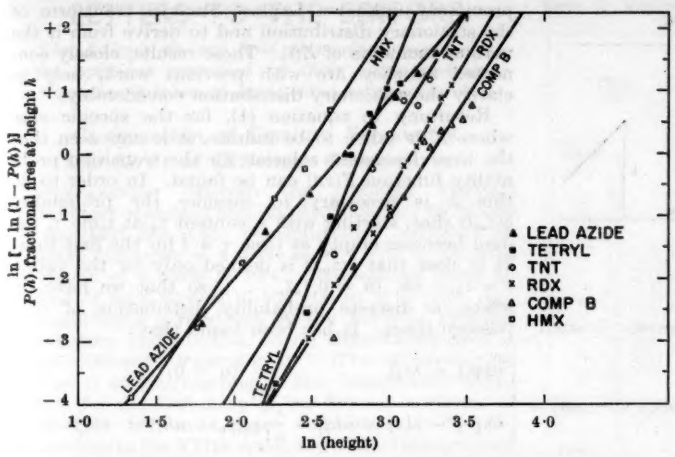

Fig. 3. $\ln [- \ln \{1 - P(h)\}]$ versus $\ln h$ should be a straight line if equation (3) applies to the data. Because of the well-known inadequacies of log–log plots this cannot be considered a good test. However, these plots are a convenient device for determining n and K and the parameters tabulated in Fig. 1 were obtained from them

which emphasizes that K is the product of two constants. By writing this as:

$$\ln K + n \ln h = \ln [- \ln \{1 - P(h)\}]$$

we can test, subject to the usual inadequacies of log–log plots, the applicability of (3), since a plot of $\ln [- \ln \{1 - P(h)\}]$ versus $\ln h$ should be a straight line of slope n. Fig. 3 is such a plot, for the data represented on Fig. 1, and it appears to be in reasonable agreement with these ideas. Furthermore, these plots are a convenient device for determining the parameters n and K. In order to determine n and K in a consistent manner, the lines shown in Fig. 3 were fitted by the method of least squares even though the data do not warrant this. The values of n and K so obtained are shown in Fig. 1 and the solid lines in Figs. 1 and 2 were computed from them. The dashed curve in Fig. 2 is drawn through the copper chlorotetrazole data to indicate the difference between it and the other curves. Note that n depends only on the mechanical properties of the explosive and its container, whereas K depends on both the mechanical properties and on the concentration of initiation sites. Thus, if one changes the number of sites in an explosive while leaving the mechanical properties unchanged, this would be reflected by a change in K, but n would remain unchanged.

Once the validity of equation 1 in the form that applies to a given impact machine and explosive has been established, it is no longer necessary to determine the entire fractional fire versus drop-height curve to characterize a sample. It is necessary to measure only enough points on this curve to determine the parameters in the equation; for example, only two points are necessary to determine equation (3) for the Picatinny Arsenal machine. Even though this treatment may give some insight into the results obtained with impact machines, a great deal of additional work must be done before these machines will be really useful tools for investigating the initiation process. For example, one possibility is a detailed study of impact machines by static and dynamic photoelastic analogues.

I wish to acknowledge the encouragement of Dr. J. V. R. Kaufman, of Picatinny Arsenal, and I am also indebted to two other members of the Picatinny staff, Mr. J. E. Abel for preparing the figures and for computations, and Mr. A. Forsyth for the results obtained with copper chlorotetrazole. This work was supported jointly by the U.S. Atomic Energy Commission and Picatinny Arsenal.

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CONTINUOUS TIME TREATMENT OF A STORAGE PROBLEM

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IN the storage problem considered initially by Moran[1] for discrete time, the content $Z_t (0 \leqslant Z_t \leqslant K-M)$ of a finite dam of capacity K is specified at the discrete times t ($t = 1,2, \ldots$) by the equation

$$Z_t = \text{Min}\,(Z_{t-1} + X_{t-1}, K) - \text{Min}(Z_{t-1} + X_{t-1}, M) \qquad (M < K)$$

where, during $(t-1, t)$, (1) independently distributed inputs X_{t-1}, each with probability distribution function $dG(x)$, $(0 \leqslant x < \infty)$, flow into the dam; (2) $\text{Min}(Z_{t-1} + X_{t-1}, K)$ indicates that any excess of $Z_{t-1} + X_{t-1}$ over K overflows; and lastly (3) a release $\text{Min}(Z_{t-1} + X_{t-1}, M)$ is made just before the time t.

For Z_t, X_t, M, K discrete, $\{Z_t\}$ is known to be a Markov chain, and equations may be framed for its stationary probability distribution in terms of the discrete input distribution $dG(x)$. By using limiting methods on this model, Moran[2,3] and Gani[4] have obtained some stationary solutions of the storage problem in continuous time. In these cases the procedure has proved cumbersome and, at least in the process described below, has obscured the simplicity of the underlying model. For this Poisson-type process, it has been possible to obtain directly the forward Kolmogorov equation which can be solved by straightforward methods.

Consider the dam of finite capacity K, the content $Z(t)$ of which is defined in continuous time $t (0 \leqslant t < \infty)$ by the equation:

$$Z(t + \delta t) = \text{Min}\,\{Z(t) + \delta X(t), K\} - \text{Min}\,\{Z(t), \delta t\}$$

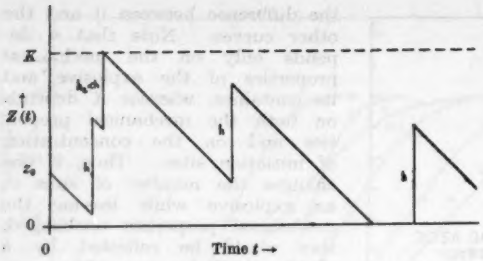

Fig. 1

$X(t)$ is a Poisson process with parameter λ such that in time δt, the input $\delta X(t)$ of either h or no units flows into the dam; the release is continuous, occurring at a constant rate when $Z(t) > 0$, and any excess of $Z(t)$ over K overflows. It is easily seen that $\{Z(t)\}$ is a time-homogeneous Markov process, of which Fig. 1 will illustrate a realization. In this particular case, the second input is effectively less than h owing to the overflow rule, and the dam remains empty for a while after the third input.

$$g(z_0, z_0 + nh) = \begin{cases} \exp(-\lambda z_0) & (n = 0) \\ \exp\{-\lambda(z_0 + nh)\} \times \dfrac{\lambda^n}{n!} z_0 (z_0 + nh)^{n-1} & (n \geqslant 1) \end{cases} \quad (3)$$

$$F(0, \tau;\ 0, \tau + t) = \begin{cases} \exp(-\lambda t) & (0 \leqslant t < h) \\ \exp(-\lambda t)\{1 + \sum_{r=1}^{n} \dfrac{\lambda^r}{r!}(t - rh)^{r-1}\} & (nh \leqslant t < (n+1)h) \end{cases} \quad (4)$$

This is actually the basic model used by both Moran[2] and Gani[4]; in Moran's model, however, the content is equal to our $K - Z(t)$, the input to our steady release and the release to our input h. In the discrete form, owing to the different formulations of the problem, the identity of the model was not recognized, and slightly different expressions for the stationary distribution of the dam content were obtained, which are in effect identical.

Let us denote by $F(z,t)$ the transition probability function $F(z_0, \tau;\ z, \tau + t)$ of the process $\{Z(t)\}$; the forward Kolmogorov relation is the differential-difference equation:

$$\frac{\partial F}{\partial t} - \frac{\partial F}{\partial z} = -\lambda\{F(z,t) - F(z-h,t)\} \quad (0 \leqslant t < \infty) \quad (1)$$

a special form of Takacs's[5] more general equation, which is valid in every part of the range $0 \leqslant z \leqslant K$, including its end points. In addition, $F(z,t) = 0$ for $z < 0$, and $F(K,t) = 1$, for all t. When $K \to \infty$, the equation continues to hold.

To find the stationary distribution $\Phi(z) = \lim_{t \to \infty} F(z,t)$, $\dfrac{\partial F}{\partial t}$ is put equal to zero in (1) and $\Phi(z)$ then satisfies the equation:

$$\frac{\partial \Phi}{\partial z} = \lambda\{\Phi(z) - \Phi(z-h)\} \quad (0 \leqslant z \leqslant K) \quad (2)$$

where $\Phi(z) = 0$ if $z < 0$, and $\Phi(K) = 1$; this leads to the results already obtained by the two different approaches mentioned. When K is infinite, a stationary solution exists if the condition $\lambda h < 1$ is satisfied, and it can now be seen that the solution here remains of a form identical with that of the known finite case. In effect, the solution for the finite dam is the truncated infinite solution with suitable scaling for $\Phi(K)$ to be equal to unity. It is now also possible from equation (2) to find the previously unknown Laplace–Stieltjes transform of the stationary distribution and to derive from it the various moments of $Z(t)$. These results, closely connected as they are with previous work, help to clarify the stationary distribution considerably.

Returning to equation (1), for the specific case where K is taken to be infinite, it is now seen that the time-dependent solution for the transition probability function $F(z,t)$ can be found. In order to do this it is necessary to consider the probability $g(z_0,t)$ that, starting with a content z_0 at time τ, the dam becomes empty at time $\tau + t$ for the first time. It is clear that $g(z_0,t)$ is defined only for the values $t = z_0 + nh$, $(n = 0,1,2, \ldots)$, so that we have, in effect, a discrete probability distribution of first passage times. It has been found that:

The probability of emptiness at time $t + \tau$, not necessarily for the first time, starting with $Z(\tau) = 0$, has also been obtained as:

where $n = 1,2, \ldots$, and by using both (3) and (4) it is possible to write the general form of the probability $P_0(z_0, t) = F(z_0, \tau;\ 0, \tau + t)$ of emptiness at time $t + \tau$ starting with $Z(\tau) = z_0$, as a convolution:

$$P_0(z_0, t) = \sum_{r=0}^{n} g(z_0, z_0 + rh) F(0, \tau + z_0 + rh;\ 0, \tau + t) \quad (5)$$

where $z_0 + nh \leqslant t < z_0 + (n+1)h$.

These probabilities finally lead to a general solution for the process $\{Z(t)\}$. The Laplace–Stieltjes transform $\Psi(\theta, t)$ of the distribution function $F(z, t)$ already defined is found to be:

$$\Psi(\theta, t) = \exp\{[\theta + \lambda(\exp(-\theta h) - 1)]\, t - \theta z_0\} - \theta \int_0^t P_0(z_0, t-u) \exp\{[\theta + \lambda(\exp(-\theta h) - 1)]u\} du \quad (6)$$

under certain general conditions, which we shall not specify here, its limit as $t \to \infty$ is easily verified to be the transform of the stationary distribution $\Phi(z)$ of equation (2). A similar result in the theory of queues, the analogies of which with the theory of storage are well known, has recently been published by Benes[6].

The work we have briefly outlined will be published in greater detail elsewhere, together with a parallel account of Moran's[3] storage problem with gamma-input. It is also proposed to present a general treatment of stochastic storage processes with inputs having certain types of infinitely divisible distributions.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Comparison of Cæsium Frequency Standards of Different Construction

COMPARISONS between the National Physical Laboratory standard and an 'Atomichron', by means of standard frequency transmissions[1], indicated an average difference of 4 parts in 10^{10} with a standard deviation of 4 parts in 10^{10}. Comparisons made by means of time signals in the course of a joint programme being carried out by the National Physical Laboratory and the U.S. Naval Observatory gave a larger difference, 9 parts in 10^{10}. This difference was discussed at the meeting of the Consultative Committee for the Definition of the Second at Sèvres in June 1957 and in a paper submitted by Dr. W. Markowitz to the XIIth Assembly of the International Scientific Radio Union at Boulder in August 1957. The desirability of carrying out direct comparisons in the same laboratory between the National Physical Laboratory standard and the 'Atomichrons' was emphasized at both meetings. Such comparisons have recently been made at the National Physical Laboratory, Teddington, in collaboration with the United States Army Signal Engineering Laboratories, Fort Monmouth, as the agency which initiated the project and supplied the 'Atomichrons', and the National Company Inc., of Malden, Massachusetts, as the contractor of the U.S. Army Signal Engineering Laboratories.

The atomic beam tubes of the 'Atomichrons'[2] differ in important respects from the National Physical Laboratory beam tube[3]; and the former are used with a servo mechanism to control the frequency of a quartz oscillator, whereas the latter is used as a resonator in terms of which the quartz clocks are calibrated. Tests, which will be described in detail elsewhere[4], were made to compare the frequencies of the standards as they are normally used, and then to determine the causes of the differences observed.

Two 'Atomichrons', Nos. 111 and 117, were first operated with their servo systems and in addition an experimental tube, No. 857 *X* 1, made by the National Company, was operated with the electronics and servo of No. 111. Their frequencies were compared with the National Physical Laboratory standard and with one of the quartz clocks, *Q*13, which was used merely to provide a continuous link throughout the measurements. The procedure was repeated after a number of realignments of the circuit controls of the 'Atomichrons' carried out by different observers in accordance with a prescribed procedure. The results are given in Table 1. It is of interest to note that the first measurement was made with the equipments as they arrived from the United States before a full realignment was made. The results for *Q*13 show that it can in general be used for interpolation over periods of a few days, although there is a small discontinuity between the values for March 24 and 26. The general drift in frequency is typical for this type of oscillator.

The beam tubes were then tested as resonators with the National Physical Laboratory driving source in order to measure the combined effect of the electronics and servo. In this test it was assumed that the National Physical Laboratory electronics, which does not involve a frequency synthesizer in the driving oscillator, produced a distortion-free micro-wave signal. The symmetry of the resonance was also measured because any asymmetry is necessarily accompanied by a shift in the peak of the curve. The asymmetry and resonant frequency were measured as functions of the radio-frequency power applied to the tubes, and in the two cases in which there was a measurable change with power it would be expected that the lowest usable power would give the frequency nearest to the true value. The error with the power used in the conditions of normal operation is given in Table 2, together with the errors due to the other effects investigated. The precision of these measurements was about $\pm 2 \times 10^{-11}$, so that although the effects are small they are significant. The limits of error given in Table 2 include the estimated systematic errors.

Table 1. FREQUENCY REPRODUCIBILITY AFTER REALIGNMENT
Frequency difference: Unit 1×10^{-10}

Date 1958	'Atomichron' No. 111 − N.P.L. standard	'Atomichron' No. 117 − N.P.L. standard	Nat. Co. No. 857 *X* 1 with 111 electronics − N.P.L. standard	*Q* 13 − N.P.L. standard
March 6	3·6	3·5		230·0
,, 7	3·8	3·6		231·8
,, 10		3·3		233·5
,, 11		4·0		233·6
,, 12		3·2	4·7	234·5
,, 14		2·5	4·2	235·3
,, 17	4·1	3·5		238·2
,, 18 (a.m.)	3·7	3·7		239·4
,, 18 (p.m.)	3·6	2·7		238·1
,, 19 (a.m.)	4·3	3·3		240·2
,, 19 (p.m.)	4·0	3·2		240·0
,, 20 (a.m.)	3·9	3·1		240·7
,, 20 (p.m.)	4·5			241·4
,, 24 (a.m.)	3·5	3·4		244·7
,, 24 (p.m.)	3·6	2·8		244·8
,, 24 (p.m.)	3·8	3·3		245·5
,, 26	3·4			244·1
,, 28	3·2			245·8
April 1 (a.m.)	3·5	3·0		249·2
,, 1 (p.m.)	3·7	2·9		249·6
,, 2	3·5	3·2		250·7
Mean	$3·7 \pm 0·3$	$3·2 \pm 0·4$	$4·5 \pm 0·3$	

The limits are the standard deviation of a single observation.

Table 2. BEAM TUBES TESTED AS RESONATORS
(Unit 1×10^{-11})

Effect	Frequency error			
	111	117	857 *X* 1	N.P.L.
Servo and electronics	$+8 \pm 4$	$+6 \pm 4$	$+20 \pm 4$	0
Asymmetry	-3 ± 7	-16 ± 7	0 ± 7	-10 ± 10
Radio-frequency power	$+4 \pm 2$	$+9 \pm 2$	0 ± 2	0 ± 5

The measured errors due to the servo, electronics and asymmetry can be applied as corrections to the mean frequencies of Table 1 provided that the difference between the resonance frequencies determined by the d.c. and a.c. (modulation) methods is negligible compared with the errors shown in Table 2. The final results of the comparisons are then as follows:

111 − N.P.L.	$2·2 \pm 1·4 \times 10^{-10}$
117 − N.P.L.	$3·2 \pm 1·4 \times 10^{-10}$
857 *X* 1 − N.P.L.	$1·5 \pm 1·4 \times 10^{-10}$

The error due to the radio-frequency power could be responsible for some of the residual differences, but as it may be linked with the others and is not fully understood, it has not been applied as a correction.

In a further test, the driving source of 117 was used to excite the National Physical Laboratory beam tube. The frequency obtained was 8×10^{-11}

higher than the value obtained with the National Physical Laboratory source, indicating that some error can be attributed to the electronics alone, apart from the servo and beam tube. Additional realignment tests were made at the conclusion of the investigation, and the results are included in Table 1.

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The Annual Pole Tide

The annual variation in latitude[1] causes a disturbance in the gravitational potential with an amplitude:

$$U = a^2 \Omega^2 m \sin\theta \cos\theta = 880 \sin\theta \cos\theta \text{ cm.}^2 \text{ sec.}^{-2}$$

where a is the radius and Ω the angular velocity of the Earth, and where m is the angular displacement of the pole along the meridian of a station located at co-latitude θ. For the annual term, Jeffreys[1] obtained $m \approx 0{\cdot}084'' = 4{\cdot}07 \times 10^{-7}$ radians, and the numerical value 880 follows from this. In comparison, the equilibrium tide S_a associated with the annual variation of the heliocentric distance has a potential[2]:

$$472(\tfrac{1}{3} - \cos^2\theta) \text{cm.}^2 \text{ sec.}^{-2}$$

The mean square values, $\int_0^{\pi/2} U^2 \sin\theta \, d\theta$, are equal to (321 cm.^{2} sec.$^{-2}$)^2 for the 'pole tide', and (141 cm.^{2} sec.$^{-2}$)^2 for the S_a, so that the pole tide is larger. Yet it appears to have been overlooked. This simply means that there is a larger effect from a movement, north or south, by 10 ft. than from a variation by 2 per cent of the Sun's distance.

The annual oceanic pole tide has an amplitude:

$$(1 + k - h)U/g = 0{\cdot}62 \sin\theta \cos\theta \text{ cm.}$$

where $k = 0{\cdot}29$, $h = 0{\cdot}59$ are the Love numbers. This is negligibly small compared to the observed tide, which has amplitude of the order of 10 cm. and is due largely to meteorological factors[3].

The disturbance in gravity due to the bodily pole tide has an amplitude:

$$\Delta g = 2(1 - \tfrac{3}{2}k + h)U/a = 3{\cdot}2 \sin\theta \cos\theta \text{ microgal.}$$

which will be difficult to observe. There is barely a possibility[4] of observing the difference in time kept by a pendulum clock (frequency $\sim \sqrt{g}$) and a quartz crystal clock. This time-difference has an amplitude:

$$\tfrac{1}{2}(\Delta g/g)(T/2\pi) = 0{\cdot}01 \text{ sec. } \sin\theta \cos\theta$$

for $T = 1$ year. The corresponding error in time-keeping for the semi-annual tide is 0·006 sec. at the equator, according to Jeffreys[5].

Thus the annual disturbance in the gravitational potential resulting from the Earth's wobble is small indeed, and worthy of note only because it exceeds the annual solar tide which is included in all text-books on the subject.

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California. May 12.

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Relative Intensities of the Oxygen Lines at 5577 A. and 6300 A. in the Night Sky

A patrol spectrograph on loan from the U.S. International Geophysical Year Committee through the Air Force Cambridge Research Center has been operating at Invercargill since August 13, 1957. This spectrograph scans a 165° strip of sky along the spectral line, the strip of sky in this case lying along the geomagnetic meridian. With exposures of the order of four to five hours on the night sky, using film with Kodak 103*a*–*F*(3) emulsion, the spectrograph has recorded the red and green lines of atomic oxygen (6300 A. and 5577 A. of OI). A preliminary analysis of 220 spectra has been carried out for the period August 13–December 31, 1957.

On some nights the 6300 A. line is considerably more intense than the 5577 A. line and on other nights the reverse is true. On many occasions it was observed that the brightness of these lines varied considerably across the sky. The relative intensity was determined by visual inspection of the film. The spectra were divided into three groups: (1) 6300 A. more intense than 5577 A., (2) 6300 A. and 5577 A. of approximately equal intensity, and (3) 6300 A. less intense than 5577 A. Each spectrum was divided into two regions, corresponding to the northern and southern sky, which were treated separately.

The relative intensity of these lines has been correlated with the magnetic *K*-indices from Amberley and Macquarie Island, these being the nearest magnetic observatories to the north and south of Invercargill respectively. The *K*-indices were averaged over the period of exposure of each spectrum.

When the relative intensity is correlated with the Macquarie Island *K*-index, it is found that for *K* equal to 0 or 1, the 5577 A. line has a high probability of being more intense than the 6300 A. line. When *K* equals 4 or greater, there is a high probability of the 6300 A. line being the dominant line. The heavy curves in Fig. 1 show the probability of the 5577 A. line (marked *G*) and the 6300 A. line (marked *R*) being the dominant line in the southern sky, plotted as a function of the Macquarie Island *K*-index. The thin curves give similar information about the spectra of the northern sky. It can be seen that there is a consistent tendency for the red to be the dominant line more often in the southern sky than in the northern sky.

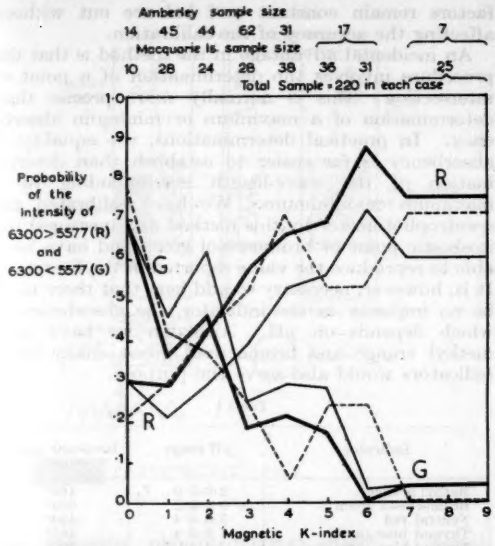
Amberley sample size
14 45 44 62 31 17 7
Macquarie Is. sample size
10 28 24 28 38 36 31 25
Total Sample = 220 in each case
Probability of the intensity of 6300>5577 (R) and 6300<5577 (G)
R
G
R
G
Magnetic K-index

Fig. 1. Relative intensity of the OI lines at 6300 A. and 5577 A. as a function of K-index. The heavy curves are the relative intensities for the southern sky plotted as a function of the K-index at Macquarie Island, the thin curves are the relative intensities for the northern sky as a function of Macquarie Island K-index and the dotted curves the relative intensities for the northern sky plotted as a function of the K-index at Amberley. The sample sizes for Amberley and Macquarie Island are given at the top of the figure

When the northern sky intensities are correlated with the magnetic K-index from Amberley (north of Invercargill), as shown by the dotted lines, then the distribution of probability for the northern sky curve is shifted into a position nearly coincident with the southern sky curve, which is plotted against the Macquarie Island K-index. The agreement between these curves (the heavy and dashed curves) over the range of K from 1 to 4 where the samples are large suggests that the relative intensity is a function of the local K-index.

About 20 per cent of the spectra fall in the group of equal intensity, which has a probability approximately independent of K-index. Of the 220 spectra obtained, auroræ were recognized as being present in about seventy cases, either from the presence of nitrogen bands in the spectra or from direct photography.

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A Comparison of Radio Echoes from the Aurora Australis and Aurora Borealis

The problem of the relation of the occurrence of auroræ in the northern and southern hemispheres is one of considerable importance to the theories of auroral formation. Hitherto, the assessment of these occurrences has been handicapped by the difficulties of the collection of simultaneous visual observations in the arctic and antarctic regions, and by the fact that in any event auroræ occur on at least 75 per cent of nights in the zones of maximum activity in which the visual observations tend to be concentrated. So far the evidence for the simultaneity of the occurrences has been largely of a statistical nature[1]. The Royal Society's Expedition to Halley Bay has provided an opportunity for a simultaneous study of the aurora australis and borealis by the radio-echo technique, and a preliminary account of the results is given in this communication.

The continuous radio-echo observations of the aurora australis have been made since May 1957 at Halley Bay, Antarctica (long. 75·5° S., lat. 26·6° W.), using a wave-length of 4 metres. The apparatus has a rotating aerial system and in principle is identical with one which has been in use at Jodrell Bank (long. 53·2° N., lat. 2·3° W.). Full details of the equipment are given in the *I.G.Y. Annals*[2]. Preliminary results on the occurrence of auroral echoes for the period May–October 1957 have been compared with the Jodrell Bank results for the same period.

Echoes from the aurora australis have been detected at Halley Bay on 134 out of 164 days of observation during the period, whereas on only 13 days were echoes from the aurora borealis obtained at Jodrell Bank. Considered on an hourly basis, observations at Halley Bay were made for 93 per cent of the time, and echoes were present for 26 per cent of the observing time, compared with 2 per cent of the time at Jodrell Bank. A study of the echo geometry at both locations shows that the echoes are obtained from the region where the line of sight is normal to the local magnetic field at a height of about 110 km. rather than from along a line of geomagnetic latitude as originally proposed by Bullough and Kaiser[3]. From Halley Bay the locus of specular reflecting points crosses the southern region of maximum visual auroral activity as given by Vestine and Snyder[4], whereas for Jodrell Bank the locus of reflecting points lies about 9° south of the northern zone of maximum auroral frequency. The disparity in rates of occurrence is therefore to be expected and is, in fact, a fortunate circumstance when considering the simultaneity of occurrence, since only the occasional auroræ coinciding with moderate to great magnetic storms are detected at Jodrell Bank.

The relation between these widespread northern auroræ and the Halley Bay results is shown in Fig. 1. The Halley Bay results show a close correlation between the number of hours a day containing echoes (irrespective of duration or amplitude) and the corresponding daily sum of the planetary magnetic K index, K_p. It can be seen that the world-wide

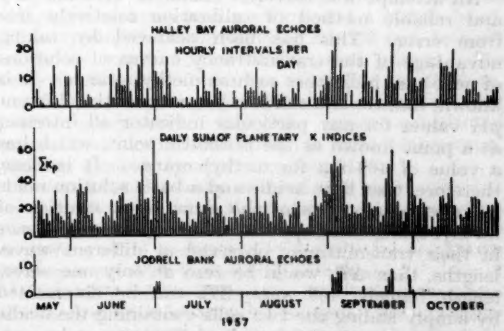

Fig. 1. Number of hourly intervals a day of auroral radio echoes detected at Halley Bay and Jodrell Bank compared with the daily sum of the planetary K index, K_p

magnetic activity maintains a strong control over the occurrence of echoes at Halley Bay over the whole range from quiet to severely disturbed conditions.

On almost all the occasions when ΣK_p exceeded about 40, echoes were obtained from the aurora borealis at Jodrell Bank, and these events coincided with the high peaks in the echo activity at Halley Bay from the aurora australis. It therefore seems reasonable to conclude that the great auroræ of the northern hemisphere are accompanied simultaneously by greatly enhanced activity of the aurora australis. It is hoped to make a more detailed study of the time correlations when the full results from Halley Bay become available.

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A Simple Technique for the Calibration of the Wave-length Scale of Spectrophotometers

It is often essential to test the calibration, setting and working of either old or new spectrophotometers. Generally, this is carried out by the standard plastic, gelatine or glass filters supplied with the instruments. Standard solutions may also be used. We were recently faced with such a problem, but found that no solid standard filters were immediately available or easily obtainable. Further, calibration and standardization with solutions is always associated with numerous difficulties of purity of chemicals and solvents and the actual preparation of standard solutions. It is well known that even chemicals labelled 'chemically pure' are sometimes contaminated. Further, departures from Beer's law and the exact range of wave-length in the so-called monochromatic beam used are also common sources of error. The problem is often complicated by systematic errors such as dichroism, colloidal particles or temperature effects.

An attempt was therefore made to find an easy and reliable method of calibration relatively free from error. This has been achieved by taking advantage of the transmittancy curves of solutions of acid-base indicators such as methyl orange. It is known[1] that the transmittancy curves for the different *p*H values for any particular indicator all intersect at a point known as the isosbestic point, which has a value of 469 mμ for methyl orange. It is clear, therefore, that if an acidic and a basic solution made from equal amounts of the same stock solution of methyl orange are kept in two cells and the difference in their transmittancy observed at different wave-lengths, then ΔT_s would be zero at only one wave-length namely, 469 mμ. ΔT_s can be determined by simply sliding the two cells containing the acidic and the basic solutions of the indicator, one by one, in the path of the beam. As this method is very similar to a null method, all the disturbing minor factors remain constant and balance out without affecting the accuracy of the calibration.

An incidental advantage in the method is that the procedure involves the determination of a point of intersection; this is normally more precise than determination of a maximum or minimum absorbency. In practical determinations, the equality of absorbency is far easier to establish than determination of the wave-length corresponding to a maximum or minimum. We have calibrated the spectrophotometer by this method and measured the isosbestic point of bromocresol green and have been able to reproduce the value reported in the literature. It is, however, necessary to add here that there must be no impurity in the indicator, the absorbency of which depends on *p*H. Although we have used methyl orange and bromocresol green, many other indicators would also serve the purpose.

Table 1

Indicator	*p*H range	Isosbestic point (mμ)
Methyl orange	2·6–5·0	469[1]
Bromocresol green	3·4–5·2	509[1]
Neutral red	5·6–8·4	480[2]
Thymol blue (acid)	1·2–3·4	485[2]
Thymol blue (alkaline)	7·4–10·2	500[2]
Phenol red	6·2–9·2	481[2]
p-Nitrophenol	5·0–9·0	350[3]

The wave-length values for the isosbestic points of a few indicators are given in Table 1. In addition, the transmittancy curves for bromophenol blue (*p*H range 2·4–5·6), methyl red (*p*H 3·4–7·0), bromocresol purple (*p*H 4·8–7·6), cresol red (*p*H 6·8–9·6) and bromothymol blue (*p*H 5·8–8·4) are given in the literature[2], from which the exact wave-length values for their isosbestic points may be ascertained.

We are not aware of any previous reports of the use of this principle for accurate calibration.

We wish to thank Dr. K. S. G. Doss, director of the Central Electrochemical Research Institute, for his useful suggestions.

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Photovoltaic Pile

In a previous communication[1], a retinal type of photovoltaic cell is described in which many inert 'point' electrodes are placed in a parallel mosaic arrangement in a small volume of photo-active solution. To indicate that each electrode is a photo-receptor, a separate d.c. amplifier is required. An attempt was then made to construct a multiple-point photovoltaic cell in which all the individual electrodes are connected in series, as shown in Fig. 1. One set of electrodes is kept dark with tape while the other is irradiated as in a thermopile. Only one amplifier[1] is of course needed for this cell. As more light- and dark-electrode pairs are added in series, larger photo-potentials are eventually generated, but at a much slower rate than with the individual point electrodes in parallel; also, with certain photo-active solutes,

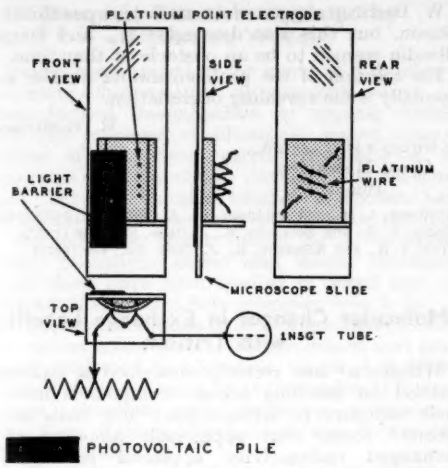

Fig. 1

the transient photo-inductive effect[2] is greatly enhanced, probably because of the presence of an oxygen-coordinated intermediate or other electron 'source' between, say, benzoin and benzil.

In Nature, perhaps the only analogy to this type of photovoltaic cell are the electric fish (electric eel, electric ray with its flat head, and electric catfish) which inhabit the upper shallow waters, but the role of light is questionable in each individual case.

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Nature of Betanin, the Pigment of Red Beet

IT has been generally supposed that the major red pigment of the root tissue of *Beta vulgaris* is composed of an anthocyanin nucleus coupled in some way with one or more amino-acids[1-4]. The other pigments, both red and yellow, are presumably very similar, with only minor variations[5]. The extreme instability of the compound and the difficulty with which it is obtained in the pure state demonstrate that these suppositions are highly speculative, at best.

In considering the previous investigations of betanin, it became obvious that certain important observations have been overlooked or misinterpreted. The most striking characteristic of betanin is its peculiar absorption spectrum. The partially purified preparations previously investigated have been reported to absorb strongly at wave-lengths shorter than 350 mμ. The pure crystalline pigment recently obtained by Wyler and Dreiding[6] exhibits only slight absorption in the region of 235–400 mμ. We have confirmed these observations by a simplified purification procedure based on an initial adsorption on a 'Magnesol-Hyflo Super Cel' column (1 : 1) followed by elution with water, precipitation as the lead salt, and conversion into the free pigment by the usual procedures[7]. Our purified preparations are characterized also by negligible absorption in the region 235–400 mμ. In this respect betanin differs markedly from any of the polyhydroxy flavylium salts. Its absorption spectrum in the near ultra-violet region definitely shows the absence of aromaticity. This is confirmed by infra-red absorption spectra recently obtained, which show conspicuous absence of aromatic C–H stretching absorption at 3·3 μ. There is a sharply defined peak at 3·0μ which may be due to the presence of an O–H or N–H group in the compound.

Crystallized betanin and purified amorphous preparations contain nitrogen in amounts varying from 5 to 8 per cent[1,4-7]. Only one amorphous preparation practically nitrogen-free was obtained[8], and the absence of nitrogen in this preparation might be explained as a possible decomposition on the ion-exchange resin used[4]. We have not been able to reduce the nitrogen content of betanin by treatment with anion-exchange resins. The nitrogen present in betanin can be assumed to be ring nitrogen and the nitrogenous constituent to be either very weakly basic or possibly acidic[7]. On the basis of this and other evidence which has been overlooked or misinterpreted, we were drawn to the conclusion that betanin contains a pyrrole nucleus. Actually Ainley and Robinson[1] reported that on alkali fusion betanin yields a colourless compound giving a positive Ehrlich test. This observation we have confirmed and extended recently.

The conclusion that betanin contains a pyrrole nucleus is supported by the spectral characteristics and all the known chemical and physical properties of the pigment. The most important evidence lies in the fact that alkali fusion of betanin yields a colourless compound giving a positive Ehrlich's test. We have been able to purify this by precipitation as the mercuric salt, followed by decomposition by hydrogen sulphide, but its identification is not yet complete. Similar breakdown products giving a positive Ehrlich test can be obtained from fusion of the second major red pigment and also from the major yellow pigment. We have also identified carbon dioxide and methylamine as fusion products from all three. Ainley and Robinson (ref. 1, p. 449) reported the evolution of a base with methylamine-like odour under these conditions.

The yellow pigments present are not only similar, but also are probably precursors of the red and purple pigments. We have noticed on several occasions that certain yellow pigments (purified on a 'Magnesol' column) when allowed to stand overnight at room temperature become red-orange in colour. These preparations are then separated on an identical 'Magnesol' column into a yellow and a purple band. This explains the uncertainty of Aronoff and Aronoff[8] as to the exact number of pigments present. We have not determined whether this is due to oxidation, but it is perhaps significant that the same purified yellow pigments react with *ortho-* or *para*-substituted aromatic amines in acid solution at room temperature, yielding pink to purple compounds.

Betanin itself is easily reduced to a yellow pigment by metallic zinc in acid solution. This reduction product is re-oxidized to red-purple by exposure to oxygen at room temperature for a few hours. Dilute hydrogen peroxide hastens the re-oxidation.

Since some of the differences reported in the isolation and characterization of betanin were probably due to genetic and ecological variation in the beet roots investigated[8], we have examined several selected strains of beets grown under the same climatic and soil conditions. These differed mainly in yield of

betanin and in the readiness with which the crude betanin could be purified.

We have used absorption in the ultra-violet as a criterion for purity and have found that pigment from the variety Green Top Bunching is most easily freed from impurities absorbing in the ultra-violet region. Indeed, pigment prepared from Green Top Bunching by the method of Pucher, Curtis and Vickery[7] is practically free from ultra-violet absorption.

On the basis of the above considerations it is concluded that betanin is a pyrrole pigment and not a "nitrogenous anthocyanin". This does not preclude the presence of "nitrogenous anthocyanins" in other plant species[9].

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The interesting communication of R. G. Peterson and M. A. Joslyn on this subject calls for some comment. In the first place, the term "nitrogenous anthocyanin" is used partly chemically (nitrogenous) and largely botanically (anthocyanin) to denote an obviously related group of water-soluble bluish-red colouring matters, such as those of *Beta*, *Atriplex*, *Celosia*, and certain Cactaceae. The only evidence favouring some form of amino-flavylium salt structure, which was the basis of a working hypothesis, was the colour and some other properties of synthetic amino-flavylium salts containing hydroxyl and methoxyl groups[1]. There was a certain resemblance between the absorption spectra in the visible region of betanin and 4′-amino-3 : 7-dihydroxyflavylium chloride. However, no phenolic degradation products could be obtained from betanidin[2]. We have always recognized that the relation to the flavylium group was unconfirmed and a purely speculative hypothesis. The evidence in favour of a pyrroloid constitution is not much stronger.

The argument from spectra is double-edged and inconclusive in the absence of appropriate models. Thus hydroxyl- and amino-substituents tend to erase fine structure in the visible region and ultra-violet spectra, while it is hard to predict with any confidence the infra-red band positions for likely structures that could explain the colour of these pigments. It is true that $C_{20}H_{23}O_7N_2Cl$ [2] could be $C_9H_9N_2Cl$ (dipyrromethene salt) $+C_6H_{10}O_5$ (sugar fragment, perhaps as in barbaloin) $+C_5H_4O_2$ (many possible interpretations), but bougainvillæidin is a member of this group of pigments with about C_{33}/N in the molecule[3].

Although it is possible that there are two (or more) types of nitrogenous anthocyans, and although a pendent C_{20} group cannot be excluded, the more natural view is that the essential content of the chromophore-cum-auxochrome may include only one nitrogen atom. Some years ago my colleague Dr. J. W. Barltrop suggested an attractive possibility for betanin, but this also demanded N_2, and bougainvillæidin seemed to be an obstacle at that time.

The solution of the problem awaits further work, especially some revealing degradation.

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Molecular Changes in Exchange Labelling with Tritium

Wilzbach[1] has recently described a convenient method for labelling organic compounds involving their exposure to tritium gas; but both he and others[2,3] found that appreciable amounts of the exchanged radioactivity appeared in traces of highly tritiated contaminants as well as in labile positions. We have applied this method to the labelling of 1 ; 6-dihydroxyhexœstrol, an œstrogen analogue[4], and similarly have found that impurities contain the major part of the incorporated non-labile tritium.

These results could be explained by a preferential exchange of tritium for the hydrogen atoms of trace amounts of impurity present in the starting material. Alternatively, highly radioactive by-products might have been formed from chemically pure material by degradation in the course of the exchange reaction.

In order to differentiate between these two possibilities, dihydroxyhexœstrol (10 mgm.) was exposed to tritium gas (200 mc.) for 14 days. The product, after removal of labile tritium, was washed three times with ether; more than 60 per cent of the radioactivity was hereby removed, although dihydroxyhexœstrol itself is virtually insoluble in this solvent. Finally, crystallization of the ether-washed material from aqueous ethanol gave a product which retained its specific radioactivity on further crystallization. On re-exposure of the purified material to tritium gas, comparable amounts of radioactive impurities soluble in ether were again formed. These radioactive contaminants are thus produced by changes in a chemically pure organic compound when it is exposed to tritium gas. Identification of the by-products is now being attempted.

These results further demonstrate the necessity for rigorous purification of radioactive compounds prepared by this useful labelling method.

We are indebted to Mr. W. Lawson, of the Middlesex Hospital Medical School, for a generous gift of dihydroxyhexœstrol.

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Chemical Reactions initiated by Ultrasonic Waves

I HAVE been engaged in the study of a number of reactions in solution caused by ultrasonic waves.

Sono-chemical decomposition of organic halides. Under the influence of ultrasonic waves aqueous solutions of chloroform, carbon tetrachloride, dichloro- and diiodo-methane, dichloro- and dibromoethane, and ethyl chloride, bromide and iodide have been found to liberate halogens[1] in both the ionic and the molecular states (tested by silver nitrate solution, potassium iodide and starch indicator). Five of these have been studied in detail and the results are summarized here (compare refs. 2–7).

(1) Aqueous solutions of dichloromethane, chloroform, carbon tetrachloride, dichloroethane and ethyl bromide subjected to ultrasonic waves (1–2 Mc./s., 225 watts electrical input to the transducer) liberate halogens, simultaneously producing polymerized solids. None of them, except chloroform, decomposes in the pure state.

(2) In all five cases only a part of the total halogen is liberated and does not seem to increase much with long exposures. The liberation of halogens increases with dilution.

(3) A considerable bulk effect is observed, probably due to the direct load of the liquid on the transducer.

(4) Organic liquids such as alcohol and acetone retard the reaction, and beyond a certain concentration the reactions stop altogether.

(5) Ultrasonic intensity influences the reaction; at higher power output the reactions are accelerated.

(6) The decompositions are of zero order and in four cases (CH_2Cl_2 not tried) the reactions proceed faster at lower temperatures.

(7) The primary sono-chemical reactions postulated are:

$$H.OH \rightarrow H + OH$$

consuming 118 kcal.

and

$$Alk\text{–}X \rightarrow Alk + X$$

consuming 68 kcal. for C—Cl and 54·5 kcal. for C—Br

where X is a halogen atom.

These reactions are supposed to be followed by hydrolysis and polymerization.

Sono-chemical decomposition of organic sulphides. The bond-strength between carbon and sulphur is 54·5 kcal., which is approximately equal to that between carbon and bromine in organic aliphatic halides. It was believed, therefore, that organic sulphur compounds would decompose in the same way as organic halides, liberating sulphur. The simplest organic sulphide, namely, carbon disulphide, was exposed to ultrasonic waves in the pure state as well as in aqueous solutions. In the pure state there was no detectable liberation of sulphur, whereas in aqueous solution a brown-coloured colloidal sol which was very stable was obtained. Similarly, with aqueous solutions of ethyl disulphide a white-coloured colloidal sol, which was very stable, was obtained. It was analysed qualitatively and the colloidal sulphur particles were observed to be of a different size-range from those from carbon disulphide. The brown sol treated with ammonia gave a brown colour, and with sulphuric acid a pink colour. When the solid obtained by centrifuging was treated with various organic solvents, a black residue was obtained which was suspected to be carbon.

On this basis the following mechanism for the decomposition of carbon disulphide is suggested:

$$CS_2 \rightarrow (CS) + S$$
$$n(CS) \rightarrow (CS)_n$$
$$(CS) \rightarrow C + S$$
$$CS_2 + H_2O \rightarrow COS + H_2S$$
$$COS + H_2O \rightarrow CO_2 + H_2S$$

Inorganic reactions initiated by ultrasonic waves. I exposed redistilled water to ultrasonic waves and observed a change in conductivity (after 1½ hr. exposure, from 4×10^{-6} to $1{\cdot}15 \times 10^{-4}$ ohm^{-1}cm.$^{-1}$), but no conclusive reactions due to the presence of hydrogen peroxide in the free state were obtained. A very dilute acidic solution of potassium permanganate was decolorized, but a very dilute acidic solution of potassium dichromate covered with a layer of ether showed no change in colour. When a slightly higher concentration of potassium permanganate was used it gave a sol at shorter periods of exposure, and after long exposure gave a brown precipitate, probably an oxide of manganese. A titanous solution exposed to ultrasonic waves was oxidized to the titanic state, losing its violet colour, but a cerous solution did not turn orange, indicating that it had not been oxidized to the ceric form. A ferrous solution was converted to the ferric state, identified by the usual potassium thiocyanate and potassium ferricyanide tests.

The experimental work reported here was carried out in the Chemical Laboratories of the University of Allahabad.

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Chemistry and Clay Mineralogy of a Soil Sample from Antarctica

A SAMPLE of soil, scraped up by Mr. A. S. Helm from Scott Base, McMurdo Sound, has been analysed by this laboratory. The material contained many well-rounded blue-grey stones of basaltic and arenaceous origin, the majority being basaltic. It was apparently derived from the basaltic rocks which outcrop in the area and mixed with material from sedimentary sources in the vicinity. No humus was apparent to the eye but the sample contained a small piece of moss as well as some bacteria (J. D. Stout, personal communication) and is thus justifiably regarded as a soil. Of the material collected, 98·6 per cent was less than 25 mm. in diameter and 64 per cent less than 2 mm. Only 2·6 per cent was less than 0·066 mm. and less than 1 per cent of clay was present.

The high *p*H value (1 : 2·5 water suspension) is apparently caused by the presence of calcium car-

Table 1. Chemical Analysis (Results on Oven-dry Basis)

pH	Phosphate soluble in 1 per cent citric acid (mgm. per cent)	C (per cent)	N (per cent)	C/N	Cation-exchange capacity (m.equiv. per cent)	Exchangeable cations (m.equiv. per cent) Ca	Mg	K	Na	$CaCO_3$ (per cent)	Total soluble salts (m.equiv. per cent)
8·5	54	0·31	0·022	14	22·6	4·7	3·6	6·5	7·4	0·13	1·3

bonate in the form of fine shell fragments. The content of phosphate soluble in 1 per cent citric acid is very high and entirely inorganic in nature. Both carbon and nitrogen figures are low and the resulting low carbon/nitrogen ratio suggests that the organic matter has undergone humification processes.

Although this soil contains very little of either clay or organic colloids, the cation-exchange capacity (neutral normal ammonium acetate procedure) is high, and Fig. 1 shows that the fine sand fractions have very high capacities and that moderately high capacities persist into the coarser fractions. These high capacities could result either from the presence of palagonitic material in the sample or to the cation-retaining powers of fractured, unleached mineral surfaces. Fig. 1 shows also that distillation with sodium hydroxide drives off more ammonium ions than does magnesium oxide; this difference, which is most apparent in the coarser fractions, seems similar to the phenomenon described by Barshad[1] which he termed "ammonium fixation".

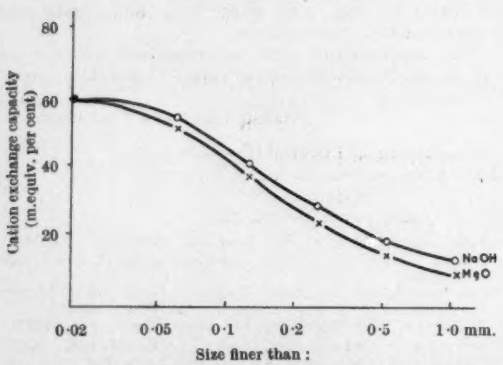

Fig. 1. Cation exchange capacity of various size fractions

The predominant feature of the individual exchangeable cations is the very high content of potassium and sodium. Total analysis showed that this material contained quite normal amounts of potassium and sodium for basic rocks, and the high exchangeable contents suggest a lack of leaching. Although free lime is present, the calcium forms only a small part of the exchangeable cations and this fact, together with the presence of water-soluble salts (mainly sodium bicarbonate and chloride), indicates that the movement of water through this soil has been very small in amount.

Clay of less than 2μ equivalent diameter was separated from the soil using sodium hexametaphosphate as dispersing agent. It was washed free of sodium ions and examined by X-ray diffraction using the dispersed sample, a potassium-saturated sample, and a magnesium-saturated, glycerol-saturated sample.

Dioctahedral mica was the main crystalline mineral present in the clay. Inter-stratified swelling and non-swelling micaceous minerals, quartz, feldspar, and a little kaolin were also found. An electron micrograph showed that some amorphous material was present.

It is unlikely that the dioctahedral mica or the quartz is derived from the basaltic stones which make up most of the material. They may have been derived from the sandstone either in place or where the sandstone forms the basement rock. If they have been derived in place they show that the weathering which has produced the material was preponderantly physical. Mica, quartz and feldspar are present in the sandstone, and have probably reached clay size by the physical process of comminution. The swelling micaceous minerals and the kaolin, which together comprise only a small proportion of the small amount of clay, are the only recognizable catamorphic products, and they may have been formed by processes occurring before the present soil-formation stages. If they were formed elsewhere, they indicate that the amount of clay formed in the present cycle of weathering and soil-formation is zero, and again indicate that physical weathering is preponderant and chemical weathering negligible.

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Different Phases of Tectonic Deformation in the Rhinns of Galloway

In the overthrust Caledonian metamorphics of Swedish Lapland there are traces of at least three main phases of deformation. This has been proved by graphic-statistical studies on the tectonics of a sequence of six small areas[1,2]. Each of the phases is distinguished by certain directions of main transport that are constant for all the areas. There is a fair amount of evidence of several kinds to establish the age-relations of the phases. First, there were transport directions toward east-south-east, then toward the south-south-east, then toward the east (and/or south ?).

The exceptionally well-exposed folded Ordovician and Silurian greywackes and shales of the Rhinns of Galloway were chosen as a test field for the hypothesis that phases of deformation with different transport directions may have affected less metamorphic strips of the Caledonides as well. The Rhinns of Galloway coast affords a classic example of the current idea of the north-western belt of the Southern Uplands of Scotland as a fan structure striking north-east – south-west, with roughly iso-

clinal folds, the limbs of which generally dip toward the central axis of the structural complex[2].

Tectonic data were collected from Broadsea Bay and southward, at eighteen fairly evenly spaced localities, each representing 200–1,000 m. of the coast. The orientations of 1,600 bedding-planes and 2,100 joints were recorded as exactly as possible. The lines of intersection (β) of the bedding-planes tend to represent fold axes. The β intersection was constructed graphically for each two succeeding bedding-planes. All β intersections were brought into synoptic diagrams, one for a north sub-area (the coast section Broadsea Bay–Morroch Bay), and one for a south sub-area (the south part of the Rhinns, including Portayew in the north). Two other synoptic diagrams were prepared for the normals of all joints recorded in each of the two sub-areas. The axes were plotted on a Schmidt net that is regarded as the lower hemisphere. The general axial plunge is 10–30° toward the north-east. The joints tend to be *ac* joints, that is to say, normal to the fold axes. There are persistent concentrations of nearly horizontal axes about N. 75° E. and N. 47° E. Axes belonging to these groups occur in both sub-areas and at different localities. Both systems frequently are met with at the same locality. For this reason, the systems cannot be due to differences in local tectonic setting. The structures striking N. 47° E. as a rule are almost isoclinal folds that are overturned toward the north-west. The N. 75° E. strikes are associated with some shattering of the beds, and important thrust zones dipping northward. The most impressive of these thrusts outcrops in the northern part of Cairngarroch Bay. Other thrusts are just north of Clanyard Bay. Deformations belonging to this group affect structures of the first group. There is thus evidence of at least two important post-Llandoverian phases of deformation in this part of the Uplands, one phase with transport mainly toward N. 43° W., and another, later, with transport mainly toward S. 15° E. The former phase has determined the main regional strike; the latter has converted the area of greywacke beds, dipping to the south-east, into a fan structure. It would be interesting to discover whether the same deformations can be traced farther to the north-east, along the strike of the Uplands.

Some details of the synoptic diagrams must at present be left without explanation. However, some steeply plunging fold axes of the north sub-area are largely derived from Morroch Bay, where incompetent shales have been squeezed in the core of an anticlinal structure of greywackes and split up into lenticles. These lenticles could have slipped past one another laterally, in adjustment to the squeezing. The folds seem to represent $B \perp B'$ of Sander[4].

It is obvious that with tectonites like these, joints can help to answer several questions.

A more complete account of this investigation is being prepared.

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Pancrinogen: a New Zymogen of Proteolytic Enzyme from Beef Pancreas

THREE zymogens of proteolytic enzyme in pancreas (two chymotrypsinogens and trypsinogen) are known at present. In this communication, we report the occurrence of another inactive precursor of proteolytic enzyme in beef pancreas.

Fresh beef pancreas was treated according to the method of Kunitz and Northrop[1], up to the separation of chymotrypsinogens and trypsinogen at 62 per cent saturation with ammonium sulphate (*p*H 4·2). Then the mother liquor was brought to 75 per cent saturation with solid ammonium sulphate. The resulting precipitate was collected by centrifugation and dissolved in one and a half volumes of ice-water (*p*H 4·2). To each 100 ml. of the solution 22·3 gm. of solid ammonium sulphate was added and the precipitate was centrifuged off. The supernatant was dialysed against 0·2 *M* solution of potassium chloride, previously adjusted with acetic acid to *p*H 4·2. The dialysed solution contained the bulk of the new zymogen. As all operations were carried out at *p*H 4·2 and 5° C., the possibility of bacterial activity was eliminated.

The partially purified zymogen did not show any detectable proteolytic activity toward gelatin or casein. At *p*H 8·0, the zymogen was autocatalytically transformed to active enzyme (Fig. 1). The activation of the zymogen was also induced by the addition of a trace amount of pancrin, which was prepared from a commercial porcine pancreatin by Grant's method[3]. Especially purified pancrin from beef pancreas, which was completely free from trypsin and chymotrypsin, also catalysed the activation of the zymogen at 10° C. for 32 hr. or at 37° C. for 1 hr. The latter condition eliminates the possibility of bacterial activity. It required more than 72 hr. for full activation of the zymogen in 0·2 *M* phosphate buffer, *p*H 8·0, at 10° C. without the addition of pancrin, and no activation was observed at *p*H 4·6, even in the presence of added pancrin. The zymogen

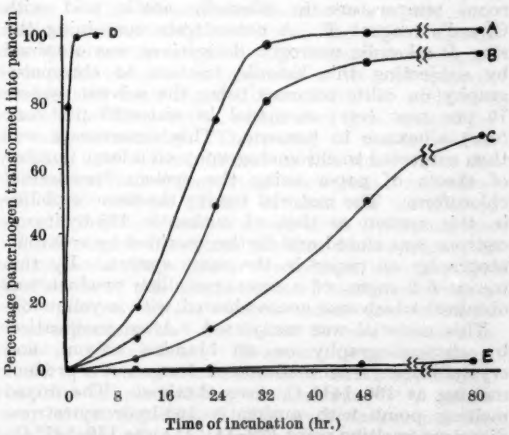

Fig. 1. Activation of pancrinogen: determination of proteolytic activity being carried out by Northrop's method (ref. 3) with 5 per cent gelatin in 0·2 *M* phosphate buffer of *p*H 8·0 at 37° C. for 15 min. Curve *A*, pancrin from beef pancreas in phosphate buffer, *p*H 8·0 at 10° C.; *B*, pancrin from porcine pancreatin, *p*H 8·0, 10° C.; *C*, autocatalytically, *p*H 8·0, 10° C.; *D*, pancrin from beef pancreas, *p*H 8·0, 37° C.; *E*, pancrin from beef pancreas, *p*H 4·6, 10° C.

was not activated by commercial crystalline trypsin during the incubation of 1 hr. at 37° C.

The active enzyme obtained from the zymogen is identical with the 'pancrin' of Grant.

These results indicate the occurrence of a new zymogen of proteolytic enzyme, which we propose to call 'pancrinogen'. Full details of this work and related problems will be published elsewhere.

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Isolation of 16β-Hydroxyœstrone from the Urine of Pregnant Women

Having been informed that we had succeeded in isolating 16β-hydroxyœstrone from the urine of pregnant women, Dr. T. F. Gallagher of the Sloan-Kettering Institute, New York, most courteously suggested to us that we should publish a preliminary account of our work simultaneously with his own announcement of the detection of the same compound by reverse isotope dilution in the urine of a human subject after the administration of œstradiol-17β-16-^{14}C (succeeding communication). The completion of our own work would have been delayed by many months if Dr. Gallagher had not provided us, before publication, with details of his method[1] for synthesizing 16β-hydroxyœstrone from œstrone *via* the enol diacetate of the latter. It is a pleasure to acknowledge his generous co-operation.

Pooled late-pregnancy urine (200 l.) was hydrolysed enzymically as previously described[2], extracted with ether and the extract washed with an aqueous solution of sodium bicarbonate and with water. The ketonic fraction of this material was obtained by reaction at room temperature in ethanolic acetic acid with Girard's reagent *T*. A concentrate containing the ring *D* α-ketolic œstrogen derivatives was obtained by subjecting this ketonic fraction to chromatography on celite columns using the solvent system 70 per cent (v/v) methanol in water/20 per cent (v/v) *n*-hexane in benzene. This concentrate was then subjected to chromatography on a large number of sheets of paper using the system formamide/chloroform. The material having the same mobility in this system as that of authentic 16β-hydroxyœstrone was eluted and further purified by rechromatography on paper in the same system. By this means 6·2 mgm. of a semi-crystalline product was obtained which was contaminated with a yellow oil.

This material was acetylated. After purification by chromatography on an alumina column and crystallization from methanol, 2·1 mgm. of a product melting at 138–141° C. were obtained. The mixed melting point with authentic 16β-hydroxyœstrone diacetate (melting point 139–141° C.) was 139–141° C., and the infra-red spectra of the two acetates (kindly determined by Dr. R. Norman Jones, National Research Council, Ottawa) were identical.

The isolation of 16β-hydroxyœstrone from the urine of pregnant women and the demonstration by Gallagher *et al.* that it is formed metabolically from administered œstradiol-17β provide support for the view[2-4] that 16α-hydroxyœstrone and 16β-hydroxyœstrone are the intermediates in the metabolic 'hydration' of œstrone to œstriol and 16-*epi*-œstriol respectively.

In the course of the same work we have also isolated 16-oxoœstradiol-17β (as its acetate). So far as could be determined, the latter compound could not have been formed as an artefact from either 16α-hydroxyœstrone or 16β-hydroxyœstrone by the methods employed in its isolation. The view previously expressed[3] that extracts of pregnancy urine contain no 16-oxoœstradiol-17β other than that which is formed artefactually during the isolation process is now seen to have been incorrect, and the criticisms based on this view of the work of Levitz, Spitzer and Twombly[5] are now unreservedly withdrawn.

Full details of this work will be published elsewhere.

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16β-Hydroxyœstrone, a Metabolite of Œstradiol in Man

The *in vivo* metabolism of œstradiol-17β leads to the formation of ring *D* ketols with a hydroxyl group at C_{16}. These compounds are of interest because they may be either intermediates in the further transformation of œstrone or end products formed from the oxidation of ring *D* glycols. 16α-Hydroxyœstrone has been isolated from the urine of pregnant women by Marrian, Watson and Panattoni[1]. This communication reports the identification of the recently synthesized 16β-hydroxyœstrone[2] as a metabolite of œstradiol-17β in man. The product is formally related to the œstrogen metabolite $\Delta^{1,3,5(10)}$-œstratriene-3,16β,17β-triol[3].

Œstradiol-17β-16-^{14}C (approximately 0·5 mgm. containing a total of $1{\cdot}5 \times 10^6$ c.p.m.) was administered intravenously to a woman with cancer of the breast. The urine collected for five days after this dose was treated with β-glucuronidase, extracted with ether, and a crude phenolic plus neutral fraction was obtained after washing with 9 per cent sodium bicarbonate solution. (β-Glucuronidase, known as 'Ketodase', was obtained from the Warner–Chilcott Laboratories, a division of Warner–Lambert Pharmaceutical Company, New York.) A portion of this extract containing 40,000 c.p.m. was subjected to chromatography on papers 4 ft. long in the solvent system toluene/*iso*octane (3 : 1) as the moving phase and methanol/water (4 : 1) as the stationary phase. In this way the total ketol fraction was separated from the less polar œstradiol, œstrone and 2-methoxyœstrone and from the more polar epiœstriol (3, 16β, 17β) and œstriol (3, 16α, 17β). Appropriate standards were chromatographed simultaneously and detected with the ferric chloride – potassium ferricyanide reagent; areas containing radioactive œstrogen meta-

bolites were located with a strip counter. The separated ketol fraction, after elution from the paper, was resubjected to chromatography in the same solvent system or with formamide and chloroform. In both systems a broad band of radioactivity was present in the area of 16α-hydroxyœstrone and 16-ketoœstradiol-17β which moved very close to each other; it was not possible to achieve a clean separation of these two compounds. However, 16β-hydroxyœstrone travelled more slowly and a distinct separation of this compound from the other two ketols was possible. A peak of radioactivity in the ketol area moved with the 16β-hydroxyœstrone standard. This latter area was eluted, mixed with a pure sample of 16β-hydroxyœstrone and resubjected to chromatography in the toluene/*iso*octane : methanol/water system. There was no separation of the radioactivity from the carrier compound. Repetitions of this experiment yielded sufficient material for reverse isotopic dilution by recrystallization to constant specific activity. The product, as it was removed from the papers, contained 57 c.p.m. per mgm., and successive recrystallizations gave values of 32, 22, 26, 22, 21 c.p.m. per mgm. It should be noted that while the final specific activity of the compound was low, the total amount of radioactivity taken for isolation was small and it was necessary to add sufficient inactive material to obtain five successive recrystallizations.

From the amount of radioactivity present in the various areas of the chromatogram, it was estimated that the total ketol fraction contained about 10 per cent of the radioactivity in the urine extract. 16β-Hydroxyœstrone was estimated to be one-third of the ketol fraction or approximately 3 per cent of the urinary radioactivity. In the particular experiment described, epiœstriol (3, 16β, 17β) was estimated to account for approximately 6 per cent and œstriol (3, 16α, 17β) approximately 30 per cent of the total urinary radioactivity. Whether the 16-hydroxy ring *D* ketols are derived from the hydroxylation of œstrone or from oxidation of the corresponding triols will be the subject for future studies.

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Biological Deamidation of Nicotinamide in Vertebrates

AN enzyme bringing about the deamidation of nicotinamide was demonstrated for the first time in lactic acid bacteria[1] and later in yeast[2] and *Mycobacteria*[3]. Studies in this laboratory have revealed the presence of nicotinamide-deamidating enzymes in *Neurospora crassa*[4] and the insect larva *Corcyra cephalonica* St.[5] and that the predominant feature of the vitamin metabolism in these organisms is the deamidation of nicotinamide. In the course of a study of the comparative metabolism of the vitamin in a variety of organisms, the liver and the kidney of several vertebrates have been examined for nicotinamide deamidase activity. A cell-free homogenate of the tissue was prepared in ice-cold distilled water and the enzyme activity measured as described earlier[4]. The results are presented in Table 1.

Table 1. DISTRIBUTION OF NICOTINAMIDE DEAMIDASE IN VERTEBRATE TISSUES

Nicotinamide deamidase activity is expressed as free nicotinic acid released (μgm.) in 60 min. at 37° C. in a 2-ml. system by cell-free homogenate equivalent to 100 mgm. of fresh tissue

Organism	Nicotinamide deamidase activity	
	Liver	Kidney
Rat	0·3	0·4
Rabbit	15·0	3·8
Guinea pig	5·0	1·6
Sheep	4·5	1·5
Hog	4·8	2·1
Cattle	2·7	1·5
Pigeon	252·0	760·0
Chick	0·7	>219·0*

* Complete deamidation of added nicotinamide in the incubation system.

It is seen that the tissues of the rat, guinea pig, sheep, hog and cattle are not able to deamidate nicotinamide *in vitro*. Rabbit liver exhibits a feeble deamidating activity, the kidney being inactive in this respect. It is interesting, on the other hand, that the tissues of the avian species, the pigeon and the chick, have very high nicotinamide deamidase activity. Surprisingly, however, while both the liver and the kidney of the pigeon are rich in the enzyme, only the kidney of the chick is able to deamidate nicotinamide.

The nicotinamide deamidase activity of *N. crassa*, *Mycobacteria* and *Corcyra* is localized in the soluble intracellular cytoplasmic matter, and can be recovered in the supernatant fraction obtained on high-speed centrifugation of their homogenates. In the case of the pigeon tissues, however, less than 10 per cent of the total activity could be obtained in the supernatant. The intracellular distribution of the nicotinamide-deamidating activity in the pigeon tissues was therefore investigated. Homogenates of pigeon liver and kidney were prepared in ice-cold isotonic sucrose and centrifuged differentially[6] to yield the sub-cellular components, which were then assayed for the enzyme activity. The purity of the individual fractions was not established in this study from the biochemical and cytogenetical viewpoint; nevertheless, it is evident (Table 2) that the particulate material in either tissue contains most of the enzyme.

These results constitute the first demonstration of nicotinamide deamidase in vertebrate tissues. The significance of this deamidation of nicotinamide as a major pathway in the vitamin metabolism in birds, micro-organisms and the insect *Corcyra cephalonica* is not entirely clear. However, these organisms exhibit a common characteristic in being apparently incapable of methylating nicotinamide[4,5,7,8], unlike many other vertebrates. The methylation and the deamidation of nicotinamide are thus probably alternative pathways in the metabolism of the vitamin. If this is so, the deamidation of nicotinamide, being a hydrolytic split, should be more economical from the point of view of bio-energetics than methylation, which requires the provision of energy[8].

Table 2. Distribution of Nicotinamide Deamidase in the Subcellular Components of the Liver and the Kidney of the Pigeon

The incubation system (2 ml.), buffered at *p*H 7·5, contained nicotinamide (2·5 mgm.) and cell fraction equivalent to 50 mgm. of fresh tissue. Incubation at 37° C. for 120 min. in the case of liver and 90 min. in the case of kidney

Fraction	Liver			Kidney		
	Nicotinic acid released (μgm.)	Per cent total activity	Nicotinic acid released per mgm. nitrogen* (μgm.)	Nicotinic acid released (μgm.)	Per cent total activity	Nicotinic acid released per mgm. nitrogen* (μgm.)
Unfractionated homogenate	252·0	100·0	192·3	570·0	100·0	422·3
Nuclei	162·3	64·3	417·6	141·0	24·7	363·4
Mitochondria	83·0	32·9	389·6	334·0	58·6	1421·0
Microsomes	43·0	17·1	201·8	70·5	12·4	298·7
Supernatant	21·4	8·3	36·5	45·0	7·9	78·9

* Nitrogen present in enzyme preparation, and insoluble in trichloroacetic acid, determined by Nesslerization of a sulphuric acid–hydrogen peroxide digest.

The highly selective distribution of nicotinamide deamidase, evident from the fact that most of the vertebrates examined, the avian species excepted, do not possess the enzyme and that in the chick, whereas the liver is completely devoid of the enzyme, the kidney has it in abundance, would point to the specific nature of the enzyme as against its being a peptidase or similar enzyme acting non-specifically.

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Chromatographic Detection of Minute Quantities of Thyroxine in Serum

Efforts to detect extracted iodized compounds directly on chromatograms have been made by various authors while following the metabolism of thyroid hormones. Nevertheless, because of low sensitivity of the agents currently employed (ninhydrin, diazotized sulphanilic acid) this has proved fruitless. By modifying the original Sandell–Kolthoff reaction for iodine estimation, Bowden *et al.*[1] succeeded in detecting 0·1γ of thyroxine. The detection of thyroxine following chromatography of serum required the use of large amounts of the biological material[2]. Moreover, careful purification of the extract for chromatography was laborious and time-consuming. Efforts made so far[1,3] have likewise failed to bring about the desired results because the colour spots are of short duration.

By means of a minor modification of the procedure of Bowden *et al.* we have succeeded in detecting thyroxine in 1·0 ml. of serum. The chromatogram was sprayed with a solution (1 : 1) of ceric ammonium sulphate (0·2 *N*) – sodium arsenite (1·0 *N*) and left approximately 15 min. to dry at room temperature after a preliminary superficial desiccation. It was then passed through a 0·5 per cent solution of fluorescein in acetone, or a 5·0 per cent solution of anthranilic acid in acetone. When the chromatogram had dried in a free current of air, thyroxine was detected by means of ultra-violet light. For a visual localization of thyroxine the chromatogram was gently sprayed with a 1·0 per cent solution of *o*-toluidine in acetone instead of the fluorescein solution. Spots, pale yellow in colour, appeared on a background of dark brown. These spots remain stable for a considerable period of time and the colour contrast increases with time. The sensitivity attained by these processings is of the order of 0·01γ of thyroxine.

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Nature of the Carcinogenic Substance in Egg-Yolks

A high incidence of malignant tumours was recently reported in mice fed egg-yolks[1], and the presence of a growth-promoting factor in the yolks has been thought to be responsible for this effect[2]. This substance was found to be soluble in common fat solvents and it is contained in the non-saponifiable and non-phospholipid portion of the yolk[3].

In the course of my investigations concerned with the isolation of the tumour-enhancing factor, I have prepared a lipoid substance accelerating the growth of experimental tumours in animals as well as stimulating the incorporation of labelled methionine-^{35}S into the proteins of Ehrlich ascites carcinoma *in vitro*. Only traces of this material are present in tissues of normal mice and rats when compared with organs of tumour-bearing animals.

The active substance is readily extracted from the unsaponifiable portion of fresh tissues or frozen-dried organs by benzene, acetone or ether. It is not adsorbed on alumina columns, but retained to some extent on anion-exchange resins, from which it can be displaced by means of weak acids. A paper chromatographic procedure has been applied for the isolation of the factor from eluants after ion-exchange chromatography.

The pure material is readily soluble in water and common fat solvents, giving an intensive yellowish fluorescence and characteristic ultra-violet absorption spectra. It is labile to heat (90° C.), destroyed by repeated freezing and thawing, but not by freeze-drying. No detailed chemical analyses could so far be carried out of a very small quantity of active material which could be recovered from tissues of tumour-bearing rats. The properties of this material so far examined suggest its close relation to aromatic hydrocarbons, possibly bile acids. It is definitely

different from the phospholipid substance described by Green and Wilson[4].

When the properties of the growth-promoting substance from yolks were reported, it seemed to us worth while to examine the possible identity of this factor with the material derived from tissues of tumour-bearing animals. Application of the procedures used in the isolation of tumour-enhancing factor from animal tissues to the unsaponifiable portion of yolks gave a considerable quantity of a fluorescent substance the chromatographic behaviour and the absorption spectra of which were identical with those given by material from rat tissues. These facts strongly support our concept that the growth-promoting factor in egg-yolk and the tumour-enhancing factor are identical.

It is hoped to determine the chemical nature of this substance shortly, because considerably larger quantities of this material are available in egg-yolk than in rat tissues.

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Efficient Trace-labelling of Proteins with Iodine

IN the methods of iodination currently used only the cationic portion of the iodine molecule becomes bound to the ring structure of tyrosine, so that the theoretical efficiency of labelling is 50 per cent. In practice, efficiencies are always lower than this and may be only a few per cent when the ratio of iodine to protein used is less than one atom per molecule. Values greater than 50 per cent can be obtained by adding oxidizing agents to liberate iodine from iodide, but most if not all of these appear to affect adversely the properties of the labelled protein.

Iodine-131 monochloride was therefore prepared and used in dilute aqueous solutions for labelling proteins. Efficiencies were twice those obtained with labelled elementary iodine in similar circumstances. Essentially the same result was achieved by merely adding carrier-free radioactive iodine to inactive carrier iodine monochloride, provided the radioiodine used was free of reducing agent. (Iodine-131 condensed into *N*/50 sodium hydroxide can be obtained for this purpose from the Radiochemical Centre, Amersham, subject to an extra handling charge. Very little appears to be known about the ionic equilibria obtaining in this solution.) The radioiodine may be added to the carrier iodine monochloride, in dilute hydrochloric acid solution, before or after conversion of the iodine monochloride to hypoiodite. This step, which is indicated by the loss of the characteristic yellow colour of iodine monochloride, appears to be a prerequisite for substitution of iodine in the benzene ring of tyrosine. The conversion is best carried out by injecting a glycine buffer of *p*H 8·5 into the iodine-131 monochloride solution just prior to rapid mixing with the protein. The *p*H of the protein solution should not be higher than 9·5 since hypoiodite is unstable above this *p*H. Using this procedure 60–80 per cent of the radioactivity used was bound to proteins provided the molar ratio of iodine monochloride to protein was greater than 2. This applied to plasma albumins and globulins of various species, including some antibodies and pathological human globulins.

Lower efficiencies were obtained using lower molar ratios because of preferential utilization of the iodine monochloride for non-specific oxidations and especially of sulphydryl. The hydroxyl group of tyrosine is not ionized at *p*H 4·5 so that iodination does not occur, while oxidations proceed normally at this *p*H. Protein solutions which had been in contact with excess iodine at *p*H 4·5 and were afterwards passed through an ion exchange column to remove iodine and iodide then reacted with iodine-131 monochloride at *p*H 8–9 giving 90 per cent incorporation of the label at all molar ratios greater than 2, and 50–60 per cent incorporation at molar ratios as low as 0·1. Alternatively the approximate amount of iodine monochloride required for non-specific oxidation in each case was determined in a preliminary tracer experiment at *p*H 8–9 and this amount of inactive iodine monochloride added to a fresh portion of protein. The iodide formed was removed by ion exchange and the oxidized protein then iodinated with iodine-131 monochloride at full efficiency.

These increased efficiencies make labelling with iodine-131 a more economical procedure and one that is less hazardous to the operator since iodine monochloride has a much lower volatility than iodine. In addition, they offer the practical possibility of labelling only a small proportion of all protein molecules present. The biological behaviour of protein molecules labelled in severely competitive conditions in this way is now being studied.

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Separation and Determination of Millimicrogram Amounts of Cobalt and Microgram Amounts of Copper in Biological Material

THE chemical determination of metals chemically bound in biological material at concentrations less than 10^{-6} gm./100 gm. raises considerable difficulties. This is due to the fact that not all sensitive methods of determining metals in homogeneous material can be adapted to the treatment of samples containing organic compounds in the presence of an excess of other metals.

When undertaking the investigation of biological material, it is necessary first to separate the mineral components from the substrate by ashing the organic substances present therein, and then to select sufficiently sensitive methods for the determination of each of the various elements after they have been separated from one another. To exemplify the procedure followed, the determination of the cobalt and copper contained in whole blood has been chosen.

Available data point to a concentration of cobalt[1] of the order of 10^{-6} gm. and of copper[2] of 10^{-4} gm. in 100 gm. of whole blood. Since the amount of blood in clinical tests usually does not exceed 10 gm., the cobalt and copper contents in a sample would be of the order of 10^{-8} gm. and 10^{-7} gm. respectively.

We have separated both elements by paper chromatography from other metals (in the first place

iron) of the blood, and applied emission spectrography for their quantitative determination. The detailed description of the determination of cobalt and copper is based on the method elaborated for determining cobalt in the blood, as given in an earlier paper[3].

The blood sample, after drying and ashing in an electric oven, is dissolved in acids. The solution of the metals present in whole blood is subjected to paper chromatographic analysis, using concentrated ammonium hydroxide as solvent, and Whatman No. 1 filter paper (14·5 cm. × 20·0 cm.). The solution is laid on along a line 3 cm. from the shorter edge of the sheet. The longer sides of the latter are then sewn together at two points to form a cylinder which is placed within the chromatographic chamber, the end nearer to the layer of the substance investigated being dipped in a solution of concentrated ammonia. In the chromatographic process the ferric ion remains at the starting line, since it is bound to the hydroxyl ion forming ferric hydroxide, which is insoluble in water. The ammonium compounds of the bivalent cobalt and copper ions, which are soluble in water, migrate along the filter paper together with the solvent front. The process is interrupted when the solvent has proceeded about 10–12 cm. above the starting line; the paper cylinder is dried at 80° C. in a position inverse to that in the chromatographic chamber.

Simultaneously, two tests are made with control solutions of salts of cobalt and copper, the presence of which is detected with a solution of α-nitroso-β-naphthol.

The paper strip containing the 'solvent front' is rolled up, placed upon silver foil and ashed carefully in the reducing flame of a Bunsen burner. The foil holding the ashed strip of filter paper containing the total amount of cobalt and copper present in the blood aliquot is now employed as an electrode, the other electrode being a silver rod; the distance between electrodes is 7 mm. The wave-lengths of the spectrum range from 2500 A. to 7000 A. Photographs are taken upon *G*22 photographic plates, with 150 diaphragm breadth and 10 sec. exposure. The plates are developed with a solution of hydroquinone in alcohol for 3 min. at 18° C. The interrupting bath in 5 per cent acetic acid lasted 15 sec. On applying an acid fixer, the plates were rinsed in running water for 30 min. at 18° C. and dried in air of the same temperature.

In order to obtain spectrographic standard curves, a series of measurements was made with known cobalt and copper solutions, containing 1·0–15·0 mμgm. cobalt and 5·0–30·0 μgm. copper simultaneously. The blackening of the 3453·5 A. line for cobalt and that of the 3247·5 A. line for copper was determined microphotometrically on the same plate. Results for cobalt and copper determinations in whole human blood are shown in Table 1, and they do not differ from those published by others using different methods.

Table 1. Determination of Cobalt and Copper in Human Blood

No. of blood sample	Cobalt (mμgm.) per 100 gm. of blood	Average	Copper (μgm.) per 100 gm. of blood	Average
1	34·3	34·7	22·0	22·2
	37·0		23·0	
	33·3		22·0	
	34·3		21·8	
2	41·1	41·5	19·7	19·3
	43·3		18·6	
	41·0		20·0	
	40·6		18·8	
3	41·0	42·7	19·9	19·2
	44·0		19·0	
	42·6		19·7	
	43·3		18·3	
4	50·4	49·9	9·7	9·5
	49·0		9·1	
	51·3		10·0	
	49·0		9·3	

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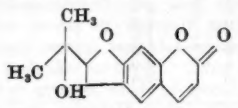
Isolation of Marmesin from the Fruits of *Ammi majus* Linn.

Ammi majus Linn. (Umbelliferae) is a wild plant which grows in Egypt, producing fruits reputed for their use in the treatment of leucodermia. They are mentioned in old Arab literature[1], and their value has recently been established by clinical investigations[2]. In 1947, Fahmy and Schönberg and their associates[3] reported the isolation of three crystalline compounds—ammoidin, ammidin and majudin—from the petroleum ether extract of the fruits. These compounds, or in any event the first two, were shown to be efficacious in the treatment of leucodermia[4–6] and are produced commercially (by The Memphis Chemical Co., Zeitoun, Cairo) for that purpose. Shortly afterwards, Schönberg[5,7] demonstrated that ammoidin and ammidin are actually the furocoumarins xanthotoxin[8] and imperatorin[9] respectively, and majudin was shown to be bergapten[4].

We wish now to report the isolation of another crystalline compound from the fruits of *A. majus*. After exhaustive extraction with benzene to remove fat and the furocoumarins mentioned above, the powdered seeds were extracted with hot ethanol and the extract, concentrated to a small bulk and hydrolysed by refluxing with mineral acid. After processing in the usual manner and repeated crystallization of the product from ethanol, a colourless crystalline compound, $C_{14}H_{14}O_4$, molecular weight 249–253 (Rast), melting point 189–190° C., was obtained in 0·25 per cent yield. The compound, optically active, $[\alpha]_D$ + 25°, sublimes unchanged at 140–150° C., 1 mm. mercury and gives a yellowish colour with concentrated sulphuric acid. The compound itself and its solution in alcohol or concentrated sulphuric acid fluoresce strongly in the blue-violet under ultra-violet light. As the compound was suspected of being another furocoumarin of *A. majus* existing naturally as a glycoside, experiments were carried out to test this possibility. (From the related *Ammi visnaga*, the furochromones khellin, visnagin and khellol glucoside were isolated; for references, see ref. 10.) The aglycone was found to be insoluble in cold aqueous alkali, but readily soluble in alcoholic alkali, giving a stable yellow solution from which the original substance is precipitated on acidification. Upon fusion with potassium hydroxide, resorcinol was obtained. The compound contained no methoxyl

or aldehydic groups and gave no ferric chloride reaction. The hydroxylic content of the compound, however, was apparently tertiary, since it did not react with diazomethane or with acetic anhydride – pyridine mixture at room temperature or upon warming. Nevertheless, a mono-acetate, $C_{16}H_{16}O_5$, melting point 130–2° C., $[\alpha]_D$ + 25 deg., was obtained by refluxing in acetic anhydride solution containing anhydrous sodium acetate. Refluxing with benzoyl chloride gave, instead of a benzoate, an optically inactive compound, melting point 134–135° C., identical with an anhydro-derivative obtained by treatment with phosphorus pentoxide. This was taken as an evidence suggesting that the hydroxyl group is close to the asymmetric centre.

Since all the evidence pointed to the possibility that the aglycone might be marmesin (I) (melting point 189·5–190° C., $[\alpha]_D$ + 26·8 deg.)—a dihydrofurocoumarin occurring freely in the bark of *Aegle marmelos*, Corrêa (Rutaceae), and first isolated by Chatterjee and Mitra[11]—other derivatives were prepared and were found to support the suggestion.



(I)

Final proof of the identity of the aglycone was sought by carrying out a determination of the mixed melting point with an authentic sample of marmesin (no depression was found) and by comparing the spectra (which were identical). Marmesin is the optical antipode of nodakenetin which occurs as a glucoside in *Peucedanum decursivum*[12]. Further experiments on the product are in progress and a study of its physiological properties is being carried out and will be reported, together with the details of this work, elsewhere.

We wish to thank Dr. A. Chatterjee for a sample of marmesin, The Memphis Chemical Co. for a generous supply of the starting material and the National Research Centre of Egypt for a scholarship (awarded to E. A. A.-M.).

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Lutein in a Bacterial Membrane

Carotenoids have been noted as constituents of a number of bacteria[1], possibly associated with protein compounds[2]. In a chemical analysis of the protoplast membrane of *Micrococcus lysodeikticus*[3], the absorption spectrum of a solution of the lipid fraction in petroleum ether, obtained by solvent extraction of the membrane, indicated the presence of lutein. However, the carotenoid was unstable in organic solvents and consequently the quantitative estimation gave a value believed to be low. It has now been found possible to determine the pigment in the membrane without preliminary extraction.

Micrococcus lysodeikticus was grown under the conditions given previously[4]. Protoplast membranes were isolated by differential centrifugation of lysozyme-induced lysates by a method previously described in detail[3]. The absorption spectrum between 300 and 800 mμ of a fresh suspension of membranes in 0·05 *M* sodium chloride solution was measured, using a 'Unicam *SP* 500' quartz spectrophotometer. As shown in Fig. 1*B*, the absorption spectrum of lutein is sharply evident, superimposed on the curve produced by the scattering of light by the suspended membranes. For comparison, the absorption spectrum of the membrane lipid dissolved in petroleum ether is given in Fig. 1*A*. With intact protoplasts, the non-specific scattering masks absorption by pigments.

In order to calculate the specific absorption in the membranes, the optical density – wave-length curve in the absence of specific absorption was calculated by a method based on Heller and Vassy[5]. A log–log plot of optical density against wave-length between 500 mμ and 800 mμ yielded a straight line of slope −2. This line was extrapolated to shorter wave-lengths

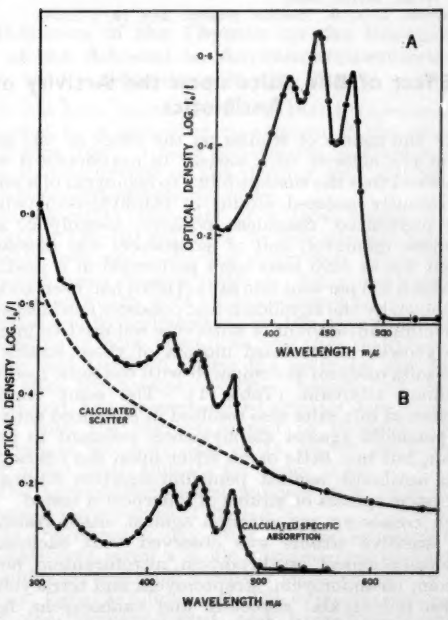

Fig. 1. Absorption spectra of *M. lysodeikticus* protoplast membrane lipid and protoplast membrane suspensions: *A*, Protoplast membrane lipid 1·1 mgm./ml. in petroleum ether; *B*, protoplast membrane suspension 0·68 mgm. dry weight/ml. in 0·05 *M* sodium chloride solution

and used to derive the calculated curve due to scatter in Fig. 1*B*. Thence, by difference, the specific absorption in the membrane was obtained.

The positions of the specific absorption peaks of the membranes are almost identical with those of lutein dissolved in hexane[6] and of the membrane lipid in petroleum ether[3]. The absorption spectrum of the membranes indicates a lutein content in the dry membrane of 0·14 per cent w/w. This is twice the value estimated on the extracted lipid[3]. Even the present estimate is probably too low, since Duysens[7] has shown that the absorption spectrum of absorbing particles, even if properly corrected for scattering, must appear flattened compared with that of the same number of molecules in a homogeneous solution.

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Effect of Bile Salts upon the Activity of Antibiotics

In the course of studies on the effect of bile salts upon the activity of a variety of antibiotics it was observed that the susceptibility to neomycin of a series of recently isolated strains of staphylococci (which are pigmented, coagulase positive, hæmolytic, and ferment mannitol) and of enterococci was increased when the *in vitro* tests were performed in a medium to which 0·5 per cent bile salts (Difco) had been added, as shown by the significant and consistent reduction in the minimum amount of antibiotic required to inhibit the growth of standard inocula of these strains in bile-salts medium as compared with the same medium without adjuvant (Table 1). The same concentration of bile salts also resulted in enhanced activity of penicillin against staphylococci resistant to penicillin, but had little or no effect upon the efficacy of this antibiotic against penicillin-sensitive strains of the same species or strains of enterococci tested. No such consistent potentiation against either resistant or sensitive strains was observed with bacitracin, chloramphenicol, erythromycin, nitrofurantoin, novobiocin, oleandomycin, streptomycin and tetracycline. With polymyxin, ristocetin and vancomycin, however, an opposite effect to that noted above was observed, namely interference, since significantly greater amounts of each of these antibiotics were required to inhibit similar inocula of a number of strains of both Gram-positive species in bile salts medium than was required in plain medium.

Table 1. Potentiation of Antibacterial Activity of Neomycin and Penicillin against Staphylococci and Enterococci by 0·5 per cent Bile Salts

Strain	Minimum inhibitory concentration of: Neomycin (μgm./ml.)		Penicillin (units/ml.)	
	Assay broth	Assay broth + 0·5 per cent bile salts	Assay broth	Assay broth + 0·5 per cent bile salts
Staphylococcus aureus				
0448	1·0	0·1	9·0	0·8
0598	0·3	0·04	4·0	1·0
0620	0·2	0·1	10·0	4·0
0196	0·4	0·03	8·0	2·0
0267	0·5	0·05	10·0	1·0
0756	0·5	0·04	0·6	0·4
1008	0·1	0·03	1·0	0·7
1020	1·0	0·1	0·4	0·4
0785	0·5	0·05	0·2	0·3
1167	0·2	0·05	0·2	0·2
Streptococcus faecalis				
0095	7·5	1·0	10·0	10·0
0145	4·0	0·5	10·0	10·0
0310	5·0	2·0	10·0	8·0
0372	4·0	0·5	10·0	10·0
0457	5·0	2·0	10·0	10·0
0485	8·0	2·0		
0491	10·0	1·0		
0608	3·0	0·5		
0668	7·5	2·0		
0779	4·0	0·4		

As regards such Gram-negative bacteria as *Escherichia coli*, *Aerobacter aerogenes*, *B. proteus* and *B. pyocyaneus*, with the exception of polymyxin, bile salts had neither an enhancing nor an antagonistic influence upon the antibiotics ordinarily employed against them, namely, chloramphenicol, neomycin, nitrofurantoin, streptomycin and tetracycline. Bile salts did interfere markedly with the action of polymyxin against these micro-organisms since considerably greater concentrations of polymyxin were required to inhibit their growth in the presence of bile salts. Thus, depending upon the antibiotic and the bacterial species against which it is employed, bile salts produce a diversity of effects, in some instances enhancement of antibacterial activity, in others interference, while in still others no effect whatever.

The medium employed in these studies consisted of 'Trypticase' 7·5 gm., 'Phytone' 1·3 gm., sodium chloride 2·15 gm. and potassium phosphate 1·05 gm. per litre of distilled water adjusted to *p*H 7·2, to which sterile 0·5 per cent bile salts (Difco) was added where indicated. Tests were performed by the tube-dilution method in 2-ml. amounts by adding 1 ml. of a 10^{-4} dilution of a culture of the strain under test (which had been maintained at 37° C. for 6 hr.), adjusted to an optical density of 0·05 on a 'Lumetron' colorimeter (650 mμ), to a series of tubes containing varying concentrations of standard antibiotic in 1 ml. of appropriate medium. Readings were taken after incubation for 24 and 48 hr. at 37° C., but since no marked changes in the observed differences between both media occurred between 24 and 48 hr., only the findings noted after incubation for 48 hr. are recorded in Table 1.

Further experiments in an attempt to elucidate the mode of action of bile salts and to determine whether an element or elements contained in the mixture might be responsible are in progress. The addition of 0·5 per cent bile salts has been found to have neither a significant stimulatory nor inhibitory

effect upon the rate or intensity of growth of the bacterial species investigated and does not change the *p*H of the medium.

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Influence of Temperature and Light on Thyroid Function

Forty-four mature male albino rats weighing 150–180 gm. were divided into four equal groups. Two of these groups were kept at a temperature of 18° C., while the other two groups were maintained at 35° C. One group maintained at each temperature was kept continuously in light of intensity 30 ft.-candles, and the other groups were kept in darkness. After 12 days the animals were killed by decapitation under light ether anæsthesia, and their blood was collected. The levels of thyroid and thyrotrophic hormone in their serum was determined by the use of the stasis tadpole method[1]. The tadpoles were divided into five groups, each of twenty animals. A control group was injected with saline. The other groups of tadpoles were injected on alternate days with five injections of 0·02 ml. of serum obtained from the four groups of rats. Increase in length of the hindlimbs of the tadpole was the criterion of thyroid hormone concentration, while the increase in thyroid epithelial cell height was used as an index of thyrotrophic hormone-level in the serum of rats. The thyroids of the rats were examined histologically. They were fixed in Zenker without acetic acid and stained with Mallory's stain[2]. Analyses of variance and of correlation were performed.

At 18° C. the thyroids of the rats kept in darkness were heavier than those of rats exposed to light. At 35° C. the thyroids of the rats exposed to light were heavier than those of rats kept in darkness. The rats kept at 18° C. had more active thyroids and higher epithelia than those kept at 35° C. These findings are in agreement with those obtained by other investigators, indicating increased activity of the thyroid under the influence of cold and decreased activity at higher temperatures[3].

The rate of metamorphosis and the epithelial cell heights of tadpoles injected with serum obtained from rats confined to darkness at 18° C. were greater than those of rats maintained at the same temperature and exposed to light. At 35° C. this effect was reversed. Exposure to light induced a significant increase in thyroid and thyrotrophic hormones in the blood, whereas darkness decreased their level. These results indicate that there is a significant interaction between the effects of temperature and light on thyroid weights and levels of thyroid and thyrotrophic hormones.

Table 1. Influence of Temperature and Light on Thyroid Function

Treatment	Data obtained from rats		Data obtained from tadpoles	
	Thyroid wt. mgm./100 gm. body weight	Epithelial cell height (μ)	Mean increase of hind limbs above control (mm.)	Mean increase of epithelial cell height above control (μ)
Cold–light	5·77±0·68	10·47±0·04	1·01±0·53	2·49±0·01
Cold–dark	7·97±0·44	11·63±0·01	5·04±0·97	4·62±0·14
Temperature–light	7·45±0·55	9·36±0·14	5·01±1·08	4·12±0·17
Temperature–dark	5·38±0·67	9·53±0·01	1·81±0·57	2·24±0·20

± Standard error.

Although the levels of thyroid and thyroid stimulating hormones were high in the blood of rats kept at 35° C. and exposed to light, yet their thyroids were inactive from the histological point of view. The thyroid-stimulating hormone produced under such conditions is probably a stimulant to thyroid secretion, rather than to cell height.

Some investigators have found that exposure of animals to light stimulated thyroid function, while others state that rats confined to darkness have more active thyroids[4]. In the light of our results, it appears that the environmental temperature can modify or even reverse the effects of light and darkness on thyroid function.

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Influence of the Thymus on the Reaction of the Adrenal to Adrenocorticotropic Hormone in the Rat

It has been shown previously that thymectomy is followed by a transitory stimulation of the adrenal in guinea pigs[1]. I have investigated whether this is due to interference of the thymus with the action of adrenocorticotropic hormone.

Eighty-eight male rats of a local inbred strain weighing 130–160 gm. were divided into two groups. Twenty-four rats in the first group were hypophysectomized, using Smith's method. Forty-eight rats in the second group were thymectomized by Segaloff's method and hypophysectomized ten days later. The technique of both operations was that described by Farris and Griffith[2]. From the sixth to the tenth day after the hypophysectomy, twenty-four thymectomized, hypophysectomized animals were injected daily with the thymus extract of Bezssonoff and Comsa[3], at the daily dose of 15, 30, 40, 50, 70 and 100 units[4] (four animals for every dose).

The hypophysectomized animals were kept at a constant temperature of 29 ± 5° C.

On the eleventh day after hypophysectomy, the animals were given a single intraperitoneal injection of adrenocorticotropic hormone (supplied by Messrs. Choay, Paris) as follows: (1) The hypophysectomized and the thymectomized and hypophysectomized animals which had not been treated with thymus extract received 0·4, 0·7, 1·0, 1·5 and 2·0 units (four animals of each group for every dose). (2) The

thymectomized and hypophysectomized animals which had received injections of thymus extract were each given 0·4 units of adrenocorticotropic hormone.

The animals were killed with chloroform two hours later, and the vitamin C content of the adrenals was determined individually by the method of Roe and Kuether.

Control determinations were performed on 8 normal male rats of the same strain, age and diet; on 4 thymectomized animals; on 4 hypophysectomized animals; on 4 thymectomized and hypophysectomized animals; and on 4 thymectomized animals injected daily for four days with 100 units of thymus extract.

In the control groups, the following vitamin C content of the adrenal was found (μgm. per mgm. of fresh tissue):

Normal males	3·16 ± 0·11
Thymectomized	1·76 ± 0·20
Hypophysectomized	7·08 ± 0·18
Hypophysectomized and thymectomized	4·20 ± 0·20
Hypophysectomized, thymectomized and injected with thymus extract	4·37 ± 0·18

Thus thymectomy was followed by a significant decrease in the vitamin C content of the adrenals. Hypophysectomy resulted in an increase of the vitamin C content in both normal and thymectomized animals. In these, thymus injections by themselves showed no additional influence on the vitamin C content.

The results with animals which received injections of adrenocorticotropic hormone are recorded in Tables 1 and 2. It can be seen that in thymectomized and hypophysectomized animals, the decrease of the vitamin C content of the adrenals (corresponding to the same doses of adrenocorticotropic hormone) is significantly greater than in simply hypophysectomized animals. The test dose of 0·4 units of adrenocorticotropic hormone produced in the first group a decrease of about one half of this content, whereas it had no detectable influence in the second. This consequence of thymectomy could be suppressed by injecting the thymectomized and hypophysectomized animals with thymus extract.

Thus the thymus is antagonistic to the action of adrenocorticotropic hormone, and its effect is supported by the thymus extract obtained by the method of Bezssonoff and Comsa.

Table 1. Vitamin C Content of the Adrenal in Rats 2 hr. after a Single Intraperitoneal Injection of Adrenocorticotropic Hormone

Adrenocorticotropic hormone dose (units)	Vitamin C (μgm./mgm. fresh weight): Hypophysectomized rats	Thymectomized and hypophysectomized rats
0	6·98 ± 0·13	4·20 ± 0·20
0·4	6·90 ± 0·20	1·85 ± 0·14
0·7	5·24 ± 0·10	1·74 ± 0·17
1·0	2·34 ± 0·18	1·44 ± 0·07
1·5	1·94 ± 0·13	1·40 ± 0·08
2·0	1·75 ± 0·05	1·38 ± 0·03

Table 2. Vitamin C Content of the Adrenal in Rats injected with Thymus Extract and 0·4 units of Adrenocorticotropic Hormone

Thymus dose (units)	Vitamin C content (μgm./mgm. fresh weight)
0	1·85 ± 0·14
15	2·02 ± 0·27
30	2·30 ± 0·09
40	2·95 ± 0·08
50	3·35 ± 0·15
70	3·71 ± 0·11
100	3·98 ± 0·17

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Effect of the Synthetic Œstrogen Stilbœstrol on Pregnancy in the Rabbit

In a communication under the above title[1], Sharaf and Hafez state that they employed very large doses of stilbœstrol (single dose, 1 mgm. in the rabbit). It is doubtful whether a dose of such magnitude could be considered to have a specific effect peculiar to œstrogens since only a few micrograms are required to produce characteristic responses. No histological work was apparently carried out to determine whether the ovum was ever fertilized and, if so, how or why the blastocyst perished. I have been working on the reproductive hormones for some time and wish to direct attention to the fact that a good deal of work has already been done in this particular field and to the results so far obtained.

Csapo[2] has demonstrated the delicate hormone balance necessary in the rabbit for the successful implantation of the blastocyst. He found that a few micrograms of œstradiol prevent implantation, an effect which was not due to 'tubal block' or to failure of the histological process of progestational proliferation. He suggested that there might be a direct effect on the blastocyst itself.

Several workers have reported on the effects of administering œstrogen during the later stages of pregnancy in mice, rabbits, rats and guinea pigs and these papers are reviewed by Reynolds[3]. The results are not altogether in agreement, since some experimenters found that injected œstrogens interrupted pregnancy, whereas others found that pregnancy continued apparently normally, despite administration of œstrogen. In the rabbit, however, it has been shown[4] that the course of normal pregnancy is determined by the level of the ovarian hormones—pregnancy being maintained by the progesterone 'block'[5] which renders the myometrium unreactive. Consequently a dose of œstrogen may be large enough to break through this progesterone block and so interrupt pregnancy, whereas any dose smaller than this 'threshold' dose would be without effect on the course of pregnancy.

The œstrogen-level obtaining in the rabbit rises steadily from the middle of pregnancy[4]. If one assumes that pregnancy is disturbed only when the œstrogen-level is raised by a certain percentage, then the threshold dose of œstrogen required to break through the progesterone block would be increased as pregnancy proceeds. This would explain the finding of several workers[3] that as pregnancy advances more injected œstrogen is required to disturb it.

These considerations suggest that the divergence of the experimental results so far reported is due to quantitative differences and to an imbalance in œstrogen dosage. A dose of œstrogen sufficient to break through the progesterone block on the fifteenth day will probably be ineffective a few days later, when a higher dose is required to produce the same propor-

tional disturbance in œstrogen-level. It would be necessary, therefore, to trace the effective dose throughout pregnancy in order to determine whether or not œstrogens, in doses small enough to have a specific action, are capable of interrupting pregnancy.

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Surface Tension of the Blood and Atherogenesis

'Triton *WR* 1339' is known to cause a marked rise of the lipæmia and cholesterolæmia when injected into experimental animals[1]. It has been suggested that the mechanism responsible for the enhancement of the cholesterol-level of the blood is an increased synthesis of cholesterol, chiefly in the liver[2], combined with an alteration in the exchange of cholesterol between the blood and the different organs. This results in a high cholesterolæmia, with normal or even lowered cholesterol-levels in the organs[3].

In order to investigate possible mechanisms to explain the rise in lipæmia, we have measured the alterations of surface tension of the blood in rabbits injected with 'Triton'. The surface tension of 5 ml. of citrated blood was measured by the platinum ring method with a du Noüy apparatus. In normal rabbits, the surface tension was found to have a constant value, the average surface tension in 140 rabbits being 57·4 dyne/cm. (standard deviation ±0·83; standard deviation of the mean ±0·07).

After a single injection of 400 mgm. 'Triton' per kgm. body-weight, an immediate fall of surface tension is observed; it is lowest 5 min. after the injection, and reverts gradually to normal values 14–21 days later. Cholesterol-levels reach a maximum after three days and become normal at about the same time as surface tension (Table 1). Smaller doses of 'Triton' have a similar but less pronounced effect on both surface tension and cholesterolæmia.

While the immediate change in surface tension can easily be explained by the influence of 'Triton' itself, the large amount of cholesterol and lipids present in the blood three days after the injection had to be examined as a possible cause of lowered surface tension. For this purpose, rabbits were given a diet consisting of pellets to which 1 per cent cholesterol and 3 per cent peanut-oil was added. Blood samples taken after 4 weeks showed a cholesterolæmia of 257·2 mgm. per cent and a surface tension of 53·9 dynes/cm. After 12 weeks the cholesterolæmia rose to 1,247 mgm. per cent, and surface tension was reduced to 51·0 dynes/cm.

Table 1. AVERAGE VALUES OF SURFACE TENSION OF BLOOD AND CHOLESTEROLÆMIA OF SIX RABBITS BEFORE AND AFTER INJECTION OF 400 MGM. 'TRITON' PER KGM. BODY-WEIGHT

	Surface tension (dyne/cm.)	Cholestorolæmia (mgm. per cent)
Before	57·0	46·5
After 5 min.	45·9	68·0
,, 3 days	47·0	349·8
,, 7 ,,	48·9	277·3
,, 14 ,,	52·2	162·5
,, 21 ,,	57·3	52·8

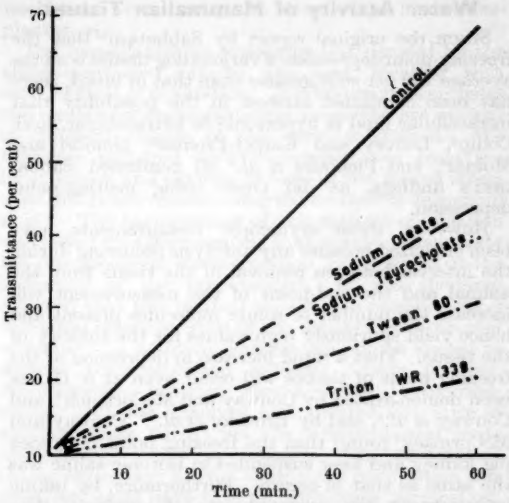

Fig. 1. Influence of surface-active agents on the heparin-clearing process *in vitro*. 1·2 ml. plasma of a rabbit injected intravenously with heparin is added to a mixture of 0·3 ml. of 1 per cent 'Ediol' and 1·5 ml. of 3 per cent albumin. Optical transmittance is measured immediately after mixing the ingredients and every 10 min. thereafter. 0·2 ml. of a solution containing 1·5 mgm./ml. of each surface-active agent to be tested was added, this bringing the final concentration to 0·1 mgm./ml. As a control the same volume of saline is used

After 12 weeks these rabbits were killed and anatomopathological examination of their aortas showed severe lipid deposits in the intima.

Another series of experiments demonstrated the inhibitory effect of various surface-active agents on the heparin-clearing mechanism *in vitro* (Fig. 1). In this blocking of the heparin-clearing mechanism, the enhanced lipæmia following injection of 'Triton' could find its explanation.

It is also of interest to note that plasma of rabbits injected with heparin failed to clear the highly lipæmic sera of rabbits injected with 'Triton', and of those that were fed the 1 per cent cholesterol diet for 12 weeks.

Other workers have found lowered surface tensions in known atherosclerotics and in a number of normal young adults[4]. In our laboratory a preliminary experiment on 10 young adults showed a definite lowering of surface tension of the blood 3 hr. after a meal chiefly consisting of saturated fats.

At this stage of investigation the exact significance of the surface tension of blood cannot be assessed. But the striking correlation between cholesterol and 'Triton' as surface-active agents and clearing inhibitors on one hand, and as atherogenous substances on the other, merits further investigation of the possible relation between lowered surface tension of the blood due to any cause, and atherogenesis.

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Water Activity of Mammalian Tissues

Since the original report by Sabbatani[1] that the freezing-point depression of various dog tissues is on the average 150 per cent greater than that of blood, there has been continued interest in the possibility that intracellular fluid is hypertonic to extracellular fluid. Collip[2], Leövey and Kerpel-Fronius[3], Gömöri and Molnár[4], and Pichotka *et al.*[5] all confirmed Sabbatani's findings, as did Opie[6] using melting-point depression.

However, these cryoscopic measurements have been criticized because any autolysis occurring during the interval between removal of the tissue from the animal and the end-point of the measurement will increase the number of solute molecules present and hence yield spuriously high values for the tonicity of the tissue. That a rapid increase in depression of the freezing point of tissues will occur even at 0° C. has been demonstrated by Conway and McCormack[7], and Conway *et al.*[8], and by Brodsky *et al.*[9]. Conway and McCormack[7] found that the freezing point of guinea pig kidney and liver suspended in isotonic saline was the same as that of serum. Furthermore, by taking into account the expected rate of autolysis, they claimed that the corrected freezing-point depression of other tissues of rat and guinea pig was also the same as that of serum. Brodsky *et al.*[9] were not able to confirm these extrapolated values (although Buckley, Conway and Ryan[10], on recalculating Brodsky's results, claim that the latter agree with those of Conway and McCormack[7]). By heating tissues in water at 98° C. for 30 min. immediately upon removal to reduce autolysis, Appelboom[11] recently has reported isotonicity with extracellular fluids.

Because of the conflicting results which have been reported and because recent workers, in attempting to circumvent autolysis, have utilized complex methods which may introduce unknown variables into the measurement, the following method employing the melting point was devised. Tissues were removed from anæsthetized animals and dropped immediately into liquid nitrogen. While still at the temperature of liquid nitrogen, the tissue was pulverized by mortar and pestle and the powder suspended in liquid silicone, a biologically inert fluid. For each measurement, a portion of tissue calculated to contain a specified amount of water was used. The plastic tube containing the mixture was placed in an evacuated, silvered jar. The mixture was then stirred rapidly and thus warmed at a constant rate

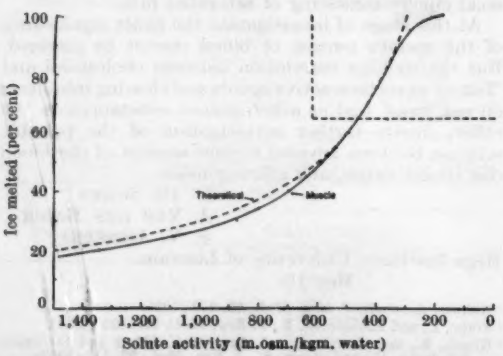

Fig. 1. Shape of the actual melting curve of rat muscle superimposed on a theoretical melting curve, a rectangular hyperbola

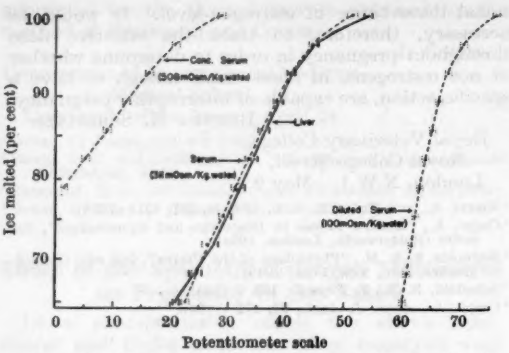

Fig. 2. Melting curves of rat liver, rat serum, concentrated rat serum and diluted rat serum

by a stirring device of low thermal conductivity. The increase in temperature of the suspension was measured with a thermistor and recorded by a continuously balancing electronic potentiometer.

Since pure water separates as ice from a solution as it freezes, one may calculate the expected melting curve of the solution. For a given solution, when the percentage of ice melted is plotted against increasing temperature, or decreasing thermodynamic activity of solute or increasing thermodynamic activity of water, a rectangular hyperbola is obtained. Such a curve is shown as the broken line in Fig. 1. Corrections for the small changes in activity coefficients which would occur over the range of concentration shown would not appreciably alter the shape of the curve and have been neglected in the present treatment. For solutions of different activities a family of rectangular hyperbolas should result.

Fig. 1 also shows an actual melting curve of rat muscle—the solid line—superimposed on the rectangular hyperbola of the theoretical curve—the broken line. The fit is close, especially in the upper portion of the curve, and it is this portion, enclosed by the broken lines, which was used as an index of depression of melting point to avoid the uncertainty of extrapolating to the point of complete melting. Over this restricted range of concentration the effect of changes in activity coefficient will be minimized.

Fig. 2 shows the mean curve obtained from twelve separate measurements of the melting curve of rat liver and a similar number of measurements of rat serum. The ordinate represents the percentage of ice melted, and the abscissa the arbitrary potentiometer scale which is proportional to temperature or activity. The mean concentration of the rat serum was found to be 311 m.osm./kgm. water by an accurate freezing-point method. To indicate the concentration scale, the melting curves of serum concentrated by drying to 508 m.osm./kgm. water and diluted with distilled water to 100 m.osm./kgm. water have been included. The small vertical bars or rows of dots indicate the standard error of the mean for each point. It is evident that the melting curve of rat liver does not differ significantly from that of rat serum. Results with skeletal muscle, heart and brain also agreed with the value for serum. The melting curve of whole rat kidney was displaced approximately 10 per cent above that of serum, a difference attributed to the production of hypertonic urine in the medullary portion of this organ. When frozen tissue was exposed to room temperature for periods of 10 and 20 min., the subsequent measurement showed a

marked increase in depression of the melting curve. This confirms that rapid autolysis will lead to spurious results.

These direct measurements demonstrate that the water activity within mammalian cells is the same as that of the extracellular fluids.

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Part played by Deoxyribonucleic Acid in Transplantation Immunity

THE tissue incompatibility revealed by homografting is due to individual antigenic differences that cause the recipient to produce an immunity response to tissues grafted from another individual. Billingham, Brent and Medawar[1] used a transplantation immunity test in inbred strains of mice when studying the antigens responsible for the homograft reaction, and formulated the hypothesis that nuclear nucleoproteins or lipoproteins associated with them were responsible for transplantation immunity. The activity of nuclear fragments was not destroyed by the action of ribonuclease or trypsin but was destroyed by the action of deoxyribonuclease. We therefore decided to test whether tissue deoxyribonucleic acid itself acts as an antigenic stimulus in homotransplantation.

The transplantation immunity test devised by the above-mentioned authors was used, together with their method of evaluation. It is known that antigens responsible for transplantation immunity are present in different tissues of the same individual. We therefore prepared deoxyribonucleic acid from the liver, spleen and thymus of mice of the inbred strain *A* or *C57* Black (males) using the method of Zamenhof *et al.*[2]. The harmlessness of this method of isolation was tested by demonstrating that it did not inactivate the pneumococcal transformation factor added at the beginning of the preparation[2]. It was therefore believed that this method should also preserve other biological characteristics of the deoxyribonucleic acid molecule. In addition, various procedures known to destroy transplantation antigens (tissue freezing, lyophilization, heating) were avoided. Deoxyribonucleic acid was dissolved and injected into mice of another strain (*CBA*) via the intraperitoneal route immediately following isolation, the preparation taking three days when a three-stage purification was used, and eight days with an eight-stage purification. The majority of these preparations contained traces of bound proteins (Table 1). Test transplantations of fresh donor skin were carried out on the fourth to fifth day after injection. Grafts were removed at the end of the sixth day after transplantation, prepared for histological examination and compared with negative and positive controls. Skin grafts on normal uninjected individuals served as negative controls and skin grafts on individuals previously immunized with tissue grafts from the same donor were positive controls.

The results show that deoxyribonucleic acid does not produce transplantation immunity comparable with immunity caused by a previous injection of donor tissue into individuals of the other strain. Only in a few cases was it possible to observe vacuolization of cells, pycnosis of nuclei of epithelial cells and an evident cellular host reaction (± in Table 1). In these respects the test grafts differed from the negative controls. The reaction after injection in these few cases did not seem to depend on either the dose of deoxyribonucleic acid or the quality of the preparation. Complete destruction of the test graft and especially its epithelial cells, as in the positive controls, was never observed, although the dose of deoxyribonucleic acid per mouse was comparatively large. This indicates that deoxyribonucleic acid by itself or with traces of bound proteins is insuffi-

Table 1

Material	Spectrum* Min.	Spectrum* Max.	N/P*	No. of mice tested	Amount injected into one mouse (mgm.)	Result of transplantation immunity test on sixth day after transplantation†
Liver *A*	235	258	1·97	6	4·6	± − − − −
Liver *C57*	235	258	2·15	2	5	− −
Spleen *A*	235	258	2·07	4	0·77	± ± −
Spleen *C57*	230	258	1·95	2	1	− −
Spleen *A*	235	260	2·22	3	1·89	± − −
Spleen *C57*	230	258	1·72	3	0·4	− − −
Thymus *C57*	230	260	2·17	1	2	−
Thymus *C57*	230	258	1·72	2	0·4	− −
Control mice, not injected						
Test graft on normal non-injected mice				11	—	− − − − − − − − − − −
Test graft on mice previously immunized with tissue				7	—	+ + + + + + +

* Total nitrogen determined by the microkjeldahl method, phosphorus by the method of Berenblum and Chain. Solutions were measured in the ultra-violet range of the SF_4 spectrophotometer (U.S.S.R.).

† − reaction indicates appearance of epithelial cells and of the whole graft as on the sixth day after transplantation in first grafts on non-injected animals; ± reaction indicates part of the epithelium destroyed, pycnotic, vacuolized nuclei, signs of cellular reaction in the graft; + reaction indicates complete destruction of epithelium.

cient to produce transplantation immunity in homotransplantation. The causes of the weak reaction found in a few cases and the general antigenic activity of isolated tissue deoxyribonucleic acid are being further studied.

We wish to thank Dr. Kohoutová of the Biological Institute for supplying and testing the pneumococcal transformation factor.

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Experiments in this laboratory on the lines described above by Hašková and Hrubešová confirm their finding that preparations of deoxyribonucleic acid may provoke a feeble transplantation immunity that is detectable by homografts of skin. Splenic nuclear fragments from mice (usually of strain *A*) were washed six times in 0·15 *M* sodium chloride or in 0·15 *M* sodium chloride – 0·01 *M* sodium versenate at *p*H 7·0. Deoxyribonucleic acid was prepared from these nuclear fragments either by the sodium xylene sulphonate method (personally communicated by Dr. N. S. Simmons) or by dissolving them in 2 *M* sodium chloride, spinning at 25,000*g* for 30–60 min., and deproteinizing the supernatant by up to nine successive emulsifications with chloroform–amyl alcohol mixture[1]. The former preparation was completed by precipitation with 0·54 vol. *iso*propyl alcohol in the presence of 0·3 *M* neutral sodium acetate, and the latter by precipitation with 0·2 vol. ethyl alcohol in the presence of 0·15 *M* sodium chloride – 0·1 *M* calcium chloride[2]. In either case the fibres of deoxyribonucleate were blotted free from excess of fluid, cut up into coarse fragments under a balanced salt solution, and allowed to swell into stiff transparent jellies. In this form they were injected into recipient mice (usually of strain *CBA*), each mouse receiving about 5 mgm. deoxyribonucleic acid. The survival scores[3,4] at six days of test skin homografts transplanted three to five days after the injection ranged from 25 per cent (indicating a definite state of sensitivity) to 100 per cent (the normal or 'control' response). Great pains were taken throughout the preparations to ensure that the deoxyribonucleic acid was in an undegraded state.

Although other possibilities have been considered (including a transformation of host cells into cells with some of the antigenic properties of the donor) there is reason for believing that the feeble sensitivity provoked by these preparations was due to an antigenic impurity, probably of a polysaccharide nature. Recent evidence[5] suggests that the determinant groups of the antigens responsible for the homograft reaction (like those which are responsible for 'enhancement'[6]) may be mucoid substances: they are inactivated by exposure to low concentrations of the periodate ion and by incubation with extracts of *Trichomonas foetus* known to contain enzymes which destroy blood-group substances in man[7]. (The *Trichomonas* preparations were very kindly supplied by Dr. W. M. Watkins.) This interpretation is not inconsistent with the fact that 'transplantation' antigens are present in washed nuclear fragments[4] and follow the deoxyribonucleoprotein through at least the earlier stages of purification, for hexosamine is now known to be present as an impurity in even quite highly purified preparations of deoxyribonucleoprotein[8]. The nucleoprotein may possibly act as an adjuvant[8], if only by presenting the antigen in a physically suitable form, and the same may be true of the deoxyribonucleate when it is injected by the method described above.

Because of its relevance to a hypothesis of 'transformation', it may be added that the repeated injection into mice, from birth onwards, of high doses of undegraded homologous deoxyribonucleic acid failed in twenty-five trials to produce any sign of transplantation tolerance, that is, failed to prolong the life of skin homografts afterwards transplanted from mice of the same strain as those which provided the deoxyribonucleic acid.

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Influence of a Crude Hypothalamic Extract on the Acid Phosphatase Activity of Rat Pituitaries

In rat pituitaries incubated *in vitro* with hypothalamic extracts the ascorbic acid content falls. Extracts of other parts of the brain are less successful[1]. This experiment was used to confirm *in vitro* the earlier findings in intact animals that hypothalamic extracts are able to stimulate the release of several trophic hormones from the distal lobe of the pituitary[2]. In the present study we tried to use acid phosphatase activity as an indicator.

Fresh rat pituitaries were incubated in the Krebs-Ringer-phosphate medium for one hour, adding either a suspension of temporal lobe of the brain (mean weight 104 mgm.) or of the hypothalamic region, including the median eminence of the tuber cinereum and the walls adjacent to the third ventricle (mean weight 86 mgm.). Each pituitary was exposed to the influence of 1 ml. of suspension for 60 min. The surface of the pituitary was then dried, the gland homogenized and the activity of acid phosphatase estimated by the method of King and Armstrong (K.A.).

In the pituitaries of male rats the activity after incubation in the pure medium corresponded to 2·04 ± 0·168 K.A. units/gm. The addition of temporal lobe suspension to the medium yielded values of 2·08 ± 0·097 K.A. units/gm. The mean figures, however, for incubation with hypothalamic extract were 2·79 ± 0·175 K.A. units/gm., the difference being thus highly significant ($P = 0·01$). Acid phosphatase activity of the brain tissue itself has no influence on the results, since in the temporal lobe 1·21 ± 0·05 K.A. units/gm. was found, practically the same value being present in the hypothalamic region (namely, 1·19 ± 0·099).

These preliminary results do not permit conclusions to be drawn. It remains to be seen whether the acid phosphatase activity in the pituitary, incubated *in*

vitro, can be utilized as a new tool in the study of the influence of hypothalamic extracts.

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Albinism in the Common or Hottentot Mole-Rat, *Cryptomys hottentotus* Lesson, 1826

During the past four years I have been compiling a preliminary list of the vertebrate fauna occurring in this National Park, situated in the Inyanga region of eastern Southern Rhodesia. During the course of these investigations it has become clear that the most common representative of the family Bathyergidae is *Cryptomys hottentotus* Lesson.

I am indebted to the assistant warden of the Park, Mr. Robert Reyers, for what would appear to be an albino specimen of this species, secured alive on April 19, 1958. This example is an adult male, with entirely white hair save in the region of the mouth and genital organs, where there is reddish discoloration from dietetic staining. The skin of the upper parts was bluish in life, and that of the under parts and feet, pink. The nails, except where suffused by blood, are white. In life the eyes were dark, with a faint suggestion of red, this latter becoming more apparent after death.

Roberts[1] lists a species *Cryptomys albus* (Roberts), the white mole-rat; and implies that he based his determinations upon three specimens, quoting (p. 398) these ". . . as the type and another specimen. There is also a buffy-yellowish specimen from Tulbagh". The distribution of this supposed species is given as "probably the Southern Cape Province only"; and attention is directed to the smaller size of the skull than in *C. hottentotus*.

The Inyanga specimen had the following measurements in life: Head and body, 125·0 mm. Tail, 12·0 mm. Hind-foot S.U., 21·0 mm.

Some skull measurements were as follows: length of skull with incisors, 37·5 mm.; zygomatic width, 24·0 mm.

The cheek teeth are simple, 4/4.

These figures come well within the range found among *C. hottentotus* secured at Inyanga, and also exceed those given by Roberts for the type of *C. albus*.

Ellerman, Morrison-Scott and Hayman[2] cite *C. albus* under the sub-heading *incertae sedis*, and Roberts mentions that Oldfield Thomas stated that the type of *C. albus* was an albino, a view shared by Ellerman, Morrison-Scott and Hayman (p. 234).

The Inyanga specimen was taken at approximately 6,000 ft. above sea-level and 32° 44′ E., 18° 17′ S.

Normal specimens of *C. hottentotus* at Inyanga are grey, darker upon the upper parts, and with a variable white head-spot which is sometimes vestigial.

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Rhodes Inyanga Estate and
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Change in Mean Viability at a Multiallelic Locus in a Population under Random Mating

A multiple allelic series at a locus can give rise to genotypes of different viabilities. Under certain conditions these genotypes can exist in equilibrium in a large random-mating population.

Owen[1] has stated necessary and sufficient conditions for such an equilibrium (when it exists) to be stable for the case of three alleles, and in attempting to generalize these conditions to the case of n alleles and to derive reasonably concise and illuminating proofs we have been led to consider the change in the mean viability of the whole population from one generation to the next. We conjecture that the mean viability increases each time the population undergoes the process of mating, but to prove this statement generally appears to be a matter of considerable mathematical difficulty. However, it is of interest to show that this is the case at least when the population is in the neighbourhood of an (existent) equilibrium, since this is sufficient for the purpose of discussing the stability of the equilibrium.

Kimura[2] and Crow and Kimura[3] state that the change in mean fitness of a population is the ratio of its additive genetic variance to the mean fitness; this is the equivalent of Fisher's[4] fundamental theorem of natural selection. However, it can be shown that their result is not applicable to the case under discussion since its derivation depends on a continuous time argument. The application of their argument to the case of discrete generations can at best be an approximation, since it is valid only for the case of infinitesimally slow selection.

Consider n alleles $A_1, A_2, \ldots A_n$ at a single locus. Let a_{ij} denote the relative viability of the genotype $A_i A_j$ ($i,j = 1, 2, \ldots n$), and let p_i ($i = 1, 2, \ldots n$) be the frequency of gene A_i ($i = 1, 2, \ldots n$) in any one generation. Let V be the mean viability of the population (supposed infinite and mating at random) in this generation, so that:

$$V = \sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij} p_i p_j \qquad (1)$$

Under random mating the frequencies p_i' of the alleles A_i in the next generation are given by the relations:

$$V p_i' = p_i \sum_{j=1}^{n} a_{ij} p_j \qquad (2)$$

The mean viability V' of the population in this next generation is:

$$V' = \sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij} p_i' p_j' \qquad (3)$$

What is required is a comparison of the values of V' and V, or, more precisely, to show that $V' - V > 0$.

Suppose now that a polymorphic equilibrium exists, and consider the population when it is in the neighbourhood of this equilibrium. Let P_i ($i = 1, 2, \ldots n$) be the equilibrium frequencies and V_e the mean viability of the population at equilibrium. Then it can be shown that:

$$V_e = \sum_{j=1}^{n} a_{ij} P_j \quad (\text{all } i = 1, 2, \ldots, n) \qquad (4)$$

Let p_i be the gene frequencies in the neighbouring state and write:

$$p_i = P_i + x_i \quad (i = 1, 2, \ldots, n) \tag{5}$$

where the x_i are small and

$$\sum_{i=1}^{n} x_i = 0 \tag{6}$$

We also write

$$X_i = \sum_{j=1}^{n} a_{ij} x_j \quad (i = 1, 2, \ldots, n) \tag{7}$$

and

$$\delta = \sum_{i=1}^{n} x_i X_i \tag{8}$$

Then a short calculation (using (4), (5) and (6)) reveals that:

$$V = V_e + \delta \tag{9}$$

In the next generation the gene frequencies p_i' are determined according to equations (2) and, after some algebra, we obtain the following expression for V':

$$V' = V + \frac{2\delta^2 - 3\delta^2 V}{V^2} + \frac{2 V_e}{V^2} \sum_{i=1}^{n} p_i X_i^2 + \frac{1}{V^2} \sum_{i,j=1}^{n} a_{ij} p_i p_j X_i X_j \tag{10}$$

Equations (4) and (5) are now used to express the difference $(V' - V)$ in terms of the P_i, X_i and V_e, together with an expression which is of higher degree than the second in the x_i, which will be denoted by $O(x_i^2)$; this yields

$$(V' - V)V^2 = V_e \sum_{i=1}^{n} P_i X_i^2 + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij} P_i P_j (X_i + X_j)^2 + O(x_i^3) \tag{11}$$

Thus, for sufficiently small values of the x_i (that is, when the population is near the equilibrium state), we have that $V' - V > 0$; hence the mean viability increases from one generation to the next.

Using this result, we can derive, in the form given by Owen, necessary and sufficient conditions for an equilibrium to be stable. These matters will be discussed in greater detail elsewhere.

One of us (S. P. H. M.) wishes to thank Dr. A. R. G. Owen for much helpful advice and encouragement; and the Royal Commission for the Exhibition of 1851 for the award of an Overseas Science Research Scholarship.

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[1] Owen, A. R. G., *Caryologia*, Supp. 6, 1240 (1954).
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Sexually Mature Individuals of *Xenopus laevis* from the Transplantation of Single Somatic Nuclei

A method of testing the potentialities of nuclei from embryonic cells has been described by Briggs and King[1]. The method consists of transferring a nucleus from an embryonic cell into an enucleated and unfertilized egg of the same species. King and Briggs[2], who have performed their experiments on *Rana pipiens*, found that normal tadpoles resulted from eggs with transplanted nuclei in about 35 per cent of cases in which the nuclei were taken from blastulæ, but in only about 6 per cent of cases in which the nuclei were taken from late gastrula endoderm; they have not reported normal development from nuclei of post-neurulæ or later stages.

We have performed similar experiments on *Xenopus laevis*. In this species we do not enucleate the eggs, because the female pronucleus participates in the development of only a very few of the transplanted eggs; these cases can be recognized by the use of a nuclear marker[3], and are excluded from our results. The marker is introduced by taking donor nuclei from a stock of mutant individuals having only one nucleolus in all cells, as opposed to wild-type individuals in which all cells contain potentially two nucleoli. Large series of observations and measurements show no differences in the embryonic development, viability, growth-rate, and fertility between mutant individuals and their wild-type full sibs. The host eggs are taken from the wild-type stock and the female pronucleus introduces an additional nucleolar organizer when it participates in development. The origin of the nuclei in transplant-tadpoles can be interpreted with certainty by knowing the ploidy and number of nucleoli.

We have found that the great majority of normal tadpoles resulting from transferred nuclei pass through metamorphosis normally. The older frogs appear to be sexually mature males and females; the rate of growth and sexual differentiation is similar in transplant-embryos and controls. In order to test the capacity of gametogenesis in transplant-individuals, we hope shortly to breed from these. Immature oocytes were found in one transplant-frog which died two months after metamorphosis.

As with *Rana pipiens*, the proportion of normal development obtainable from transferred nuclei decreases with increasing age of the donor embryo. *Xenopus laevis* gives a smaller proportion of normal development from blastula nuclei than *Rana pipiens*, but on the other hand normal development can be obtained from much later donor stages; a pre-hatching tadpole (Nieuwkoop[4] stage 32, endoderm) was the most advanced stage of donor from which a normal individual was obtained, but this was accidentally killed shortly before metamorphosis. We have also a few frogs from nuclei which have been transferred twice (serial transfers).

Table 1 gives the numbers of metamorphosed frogs that have been obtained from different germ-layers and developmental stages of donor embryos. When transplanting endoderm nuclei from post-neurula stages care has been taken to avoid using nuclei from the region of the presumptive germ-cells.

When considering our results it is important to appreciate that the normal development of eggs with transferred nuclei may mean either that the nuclei were undifferentiated and totipotent, or that they

Table 1. METAMORPHOSED FROGS WHICH RESULTED FROM TRANSPLANTED NUCLEI

Donors			Transplants		
			Metamorphosed frogs		
Stage	Germ-layer	Total transfers	No.	Percentage of total	Percentage of normal late blastulæ
Mid and late blastula	Ectoderm	565	17	3·0	12
	Endoderm	159	12	7·5	16
Early gastrula	Ectoderm	94	7	7·5	40
	Endoderm	287	12	4·2	15
Late gastrula	Ectoderm	26	2	7·7	33
	Endoderm	185	11	5·9	16·5
Neural folds	Ectoderm	9	0	0	0 out of 1
	Mesoderm	325	4	1·2	6
	Endoderm	137	7	5·1	14
Tail bud	Endoderm	163	4	2·5	9
Muscular response	Endoderm	287	1	0·35	3
Pre-hatching tadpoles	Endoderm	357	0	0	0 out of 70
Total		2,594	77		

were differentiated, but were able to return to a totipotent state as a result of developing again in the cytoplasm of an uncleaved egg.

Our results may be summarized as follows: (1) It is possible to transplant nuclei without impairing their ability to bring about normal development. (2) Some nuclei are capable of giving normal development very shortly before the organ of which they are part becomes functional; normal development was obtained from presumptive somite nuclei nine hours before the first muscular responses. (3) Normal development results from nuclei of more advanced donor stages in *Xenopus* than in *Rana pipiens*. (4) A number of monozygotic frogs have been obtained from single donors.

It may now become possible to breed from our sexually mature individuals which have developed from single somatic nuclei, and to test their genetic qualities.

We gratefully acknowledge the technical assistance of Miss A. Jewkes. This work has been made possible by contributions from the British Empire Cancer Campaign (M. F. and T. R. E.) and the Medical Research Council (J. B. G.).

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May 9.

[1] Briggs, R., and King, T. J., *J. Exp. Zool.*, **122**, 485 (1953).
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A Genetic Mechanism for 'Thread Protein' Polymorphism in Cattle

POLYMORPHISM in the 'thread proteins' of cattle sera has been described previously[1]. Four phenotypes have been found, depending on the presence or absence of one or both of a pair of threadlike zones, presumably proteins, resolved by starch-gel electrophoresis in phosphate buffer. The two zones are well separated, 'thread protein' T1 migrating more slowly than the $S\alpha$ zone, and T2 more rapidly. Individuals with only a T1 zone (phenotype T1) are readily and consistently distinguished from individuals with only a T2 zone (phenotype T2). Samples taken from the same animal at intervals up to 18 months showed the same phenotypes as the initial samples. However, individuals with both T1 and T2 zones (phenotype T1/T2) or neither zone (phenotype T0) are not differentiated consistently, T1/T2 sometimes appearing as T0. Phenotypes T1/T2 and T0, therefore, are best considered as one phenotype (T*) in practice.

The numbers of offspring obtained from the six possible matings between the three distinguishable phenotypes are shown in Table 1. The results in Table 1 were obtained (*a*) from a large self-contained local herd of pedigree Friesians, and (*b*) from matings picked at random from Friesian herds in various parts of England. Consideration of the mating results suggested that 'thread protein' polymorphism in cattle is controlled by three autosomal genes T^A, T^B and T^O, so that zone T1 is seen in the presence of T^A and zone T2 in the presence of T^B, while T^O does not evoke the appearance of either 'thread protein'. Phenotype T1 is thus an expression of the genotypes T^A/T^A or T^A/T^O, phenotype $T2$ of the genotype T^B/T^B or T^B/T^O, while phenotype $T1$/T2 has the genotype T^A/T^B and the true phenotype T^O the genotype T^O/T^O.

Table 1. OBSERVED and EXPECTED MATING RESULTS IN BRITISH FRIESIANS

Mating (phenotypes)	No. of matings (observed/expected)	Phenotypes of offspring		
		T1 (obs./exp.)	T2 (obs./exp.)	T* (obs./exp.)
	A. 96 matings in self-contained herd			
T1 × T1	12/ 9·8	8/10·3	—	4/ 1·7
T1 × T2	14/20·4	4/ 3·3	5/ 3·3	5/ 7·4
T1 × T*	28/21·3	13/15·8	5/ 2·5	10/ 9·7
T2 × T2	5/10·7	—	4/ 4·3	1/ 0·7
T2 × T*	24/22·4	2/ 2·1	17/13·6	5/ 8·3
T* × T*	13/11·6	4/ 3·9	4/ 3·9	5/ 5·1
	B. 92 matings picked at random			
T1 × T1	7/ 5·7	6/ 5·9	—	1/ 1·1
T1 × T2	19/18·7	5/ 4·2	7/ 4·8	7/10·0
T1 × T*	18/15·7	6/10·0	2/ 1·6	10/ 6·4
T2 × T2	12/15·4	—	9/10·4	3/ 1·6
T2 × T*	30/25·8	4/ 2·6	19/17·3	7/10·3
T* × T*	6/10·8	1/ 1·8	3/ 1·8	2/ 2·4

T* = Combined phenotypes (T1/T2 + T0)
No. of matings: *A*, $\chi^2 = 7{\cdot}99$; $P > 0{\cdot}1$ (5 d.f.); *B*, $\chi^2 = 4{\cdot}25$; $P > 0{\cdot}5$ (5 d.f.).
Phenotypes of offspring: *A*, $\chi^2 = 10{\cdot}76$; $P > 0{\cdot}3$ (10 d.f.); *B*, $\chi^2 = 10{\cdot}41$; $P > 0{\cdot}3$ (10 d.f.).

The gene frequencies T^A, T^B and T^O can be calculated from the relationships $p = (T^A)^2 + 2(T^A \times T^O)$, $q = (T^B)^2 + 2(T^B \times T^O)$ and $r = (T^O)^2 + 2(T^A \times T^B)$, where p, q and r are the observed frequencies of the phenotypes T1, T2 and T*. These equations are readily solved on an electronic computer, and I am indebted to J. C. Gower, of Rothamsted, for calculating gene frequencies. The equations are satisfied by two sets of frequencies; the correct set can be chosen by examination of the mating results. From 213 animals in the local herd, p, q and r were found to be 0·320, 0·333 and 0·347 respectively, and the corresponding correct set of gene frequencies were T^A, 0·280, T^B, 0·290 and T^O, 0·430. From 184 cows, heifers and calves from the matings picked at random, p, q and r were 0·248, 0·408 and 0·343, giving T^A; 0·226; T^B, 0·338, and T^O, 0·437. Using these gene frequencies, the expected distribution of offspring in each set of data has been calculated and is shown in

Table 1. Also the expected number of each of the six possible matings has been calculated in each case and compared with the actual number found. It will be seen that the observed and expected distribution of offspring agree when tested by the χ^2 test, as do the expected and observed numbers of matings. The results presented in Table 1 therefore support the genetic mechanism proposed.

Although 'thread proteins' have been found in dogs and pigs[2], no evidence of polymorphism has been found in these zones in these animals, so far. The significance of 'thread protein' polymorphism in cattle is not clear at this stage.

There does not appear to be any correlation between the thread protein phenotypes and the six β-globulin cattle phenotypes described previously[3].

I wish to thank the Directors of Lord Rayleigh's Farms Inc., and Strutt and Parker Farms, Ltd., for permission to bleed cattle, and the veterinary officers of the Milk Marketing Board for collecting blood samples from A.I. (artificial insemination) herds.

G. C. Ashton

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March 24.

[1] Ashton, G. C., *Nature*, **180**, 917 (1957).
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Bones of a Vulture among the Remains of Animals sacrificed on the "Burial of Romulus" below the *Niger lapis* in the Roman Forum

In 1899 Giacomo Boni, director of the diggings in the Roman Forum, discovered, in the area of the *Comitium*, below the *Niger Lapis*, a layer containing votive bronze statuettes and sherds attributed to the sixth to seventh century B.C., and many fragments of bones, horns and teeth of *Sus*, *Ovis*, *Taurus*, *Capra* and *Canis*, obviously remains of a sacrifice[1]. This layer was enveloping the base of the *'sacellum'*, a monument (including the famous archaic Latin inscription) which Giacomo Boni identified with the "*funestum locum in Comitio*" (Festus) which, following the Roman tradition, was supposed to be the burial of Romulus, or of his adoptive father Faustulus.

A recent revision of the skeletal remains of the sacrificial fauna collected in the above-mentioned layer by Giacomo Boni in 1899, and kept in Rome in the Antiquarium Forense (undertaken with the kind permission of Prof. P. Romanelli, "Soprintendente" to the Palatine and Forum), has led us to the identification of three fragments of bones of a vulture (Fig. 1). The fragments are: the distal part of a right humerus, with a small part of the diaphysis; the proximal part of a right ulna, with part of the diaphysis; another fragment of diaphysis of this latter bone. The three fragments belong to the same individual. The posterior face of the ulna shows two deep incisions, made on the fresh bone, by the knife of the sacrificer, when he cut the muscles of the fore-limb.

The morphology and the dimensions of the fragments indicate that they belong to a vulture of exceptionally large dimensions: either to the black vulture, *Vultur monachus* L. = *Aegypius monachus* (L.), or to the griffon vulture, *Vultur fulvus* Gmel. = *Gyps fulvus* Salvad. Owing to the extreme similarity of the osteological morphology and of the dimensions of these two species, and the fragmentary state of the bones examined, it has not been possible to reach a certain specific determination.

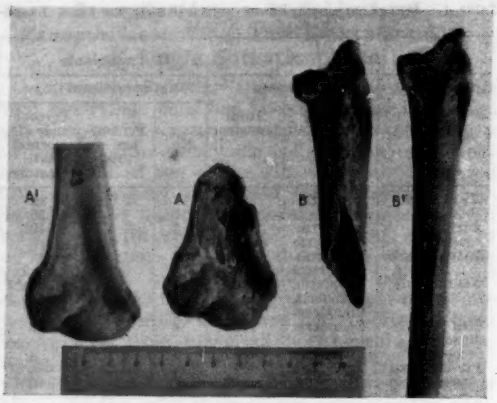

Fig. 1. *A*, distal portion of a right humerus, collected in 1899 by Giacomo Boni in the layer containing the remains of other sacrificed animals and archaic votive bronze statuettes and sherds of the sixth–seventh century B.C., underlying the *Niger lapis* in the area of the Comitium in the Roman Forum, now determined as *Vultur monachus* L. or *fulvus* Gmel. *A'*, distal portion of a right humerus of *Vultur monachus* L. (= *Aegypius monachus* (L.) Sardinia, Coll. Blanc. *B*, proximal portion of a right ulna collected in 1899 by Giacomo Boni, in the same layer as *A*, now determined as *Vultur monachus* L. or *fulvus* Gmel. *B'*, proximal portion of a right ulna of *Vultur monachus* L. (= *Aegypius monachus* (L.) Sardinia, Coll. Blanc

The vulture is a non-edible animal, difficult to capture, particularly in Roman times, and was protected by religious interdictions, being considered sacred to Mars and preferred to any other bird for taking omens.

Therefore the fact that a vulture was sacrificed, together with other victims, on the monument which was believed to be the burial of Romulus or Faustulus, should have an obvious relation with the story of the foundation of Rome, as reported by T. Livius and other classical authors. Romulus and Remus were said to have decided to settle their quarrel on where the new town had to be founded by watching the birds, believed to be the messengers of the gods. Remus watched from the Aventine Hill, Romulus from the Palatine. Remus is reported to have seen, first, the flight of six vultures, but Romulus is said to have seen twelve. Following Plutarch, Remus suspected a cheat, and moved towards his twin-brother. At that moment, Romulus really saw twelve vultures, and Remus had to accept the divine command revealed by the birds.

Titus Livius states that the first measure taken by Romulus as soon as he seized the power was to name twelve lictors, in remembrance of the twelve vultures which had announced to him the favour of the gods.

The tradition persisted for a long time, because, following P. Ovidius Naso, when Augustus became consul for the first time, he also saw twelve vultures, as was believed to have happened, seven centuries before, to the founder of Rome.

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May 20.

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FORTHCOMING EVENTS

Friday, July 11

NUTRITION SOCIETY (at Queen Elizabeth College (University of London), Campden Hill Road, London, W.8), at 10.15 a.m.—Symposium on "Applied Nutrition: The Human Factor in Group Feeding".

BRITISH PSYCHOLOGICAL SOCIETY, OCCUPATIONAL PSYCHOLOGY SECTION (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mr. Stephen Griew: "Methodological Problems in Ageing Research in Industry".

Saturday, July 12

BRITISH PSYCHOLOGICAL SOCIETY (at Birkbeck College, Malet Street, London, W.C.1), at 2.30 p.m.—Prof. B. Delisle Burns (McGill University): "Memory and Amnesia".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ADVISORY OFFICER (with a degree in science or agriculture, preferably with honours, and experience in investigational and advisory work) IN ANIMAL HUSBANDRY; and an ADVISORY OFFICER (with a degree in science or agriculture, preferably with honours, and experience in investigations or research concerning poultry husbandry) IN POULTRY HUSBANDRY; and an ASSISTANT RESIDENT SUPERVISOR (with a degree in agriculture and a special interest in animal husbandry) FOR CERTIFICATE COURSE IN AGRICULTURE—The Secretary, North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (July 10).

METALLURGIST (L.I.M. or with the H.N.C. in metallurgy or physics) at the Research Laboratories, Leatherhead, Surrey, to assist in investigating unusual problems in the creep of metals used in nuclear power generation—Chief Personnel Officer, Central Electricity Generating Board, 24/30 Holborn, London, E.C.1, marking envelope "Confidential" and quoting Ref. N.167 (July 10).

LECTURER or ASSISTANT, Grade B (with an honours degree) IN PHYSIOLOGY or PHARMACOLOGY, for duties which include teaching and research—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (July 11).

ASSISTANT (graduate in biochemistry) IN BIOCHEMISTRY in the Department of Child Life and Health—The Secretary, The University, Edinburgh (July 12).

ASSISTANT LECTURER IN ORGANIC, INORGANIC OR PHYSICAL CHEMISTRY—The Registrar, The Manchester College of Science and Technology, Manchester 1 (July 12).

ASSISTANT LECTURER (with an honours degree in psychology and additional training or experience in clinical psychology) IN CLINICAL PSYCHOLOGY in the Department of Psychiatry of the Faculty of Medicine—The Registrar, The University, Manchester (July 12).

LECTURER (with a good honours degree in applied mathematics or engineering science, and preferably research experience) IN CIVIL ENGINEERING—The Registrar, The University, Birmingham (July 14).

LECTURER IN THE POSTGRADUATE DEPARTMENT OF APPLIED MECHANICS—The Registrar, The University, Sheffield (July 19).

RESEARCH ASSISTANT IN MATHEMATICAL STATISTICS in the Department of Applied Mathematics—The Registrar, The University, Liverpool (July 19).

RESEARCH ASSISTANT IN THE UNIT OF BIOMETRY, for duties mainly concerned with the design and analysis of radiobiological experiments in conjunction with the Agricultural Research Council radiobiological laboratory at Grove—The Reader in Biometry, The University, 7 Keble Road, Oxford (July 19).

RESEARCH ASSISTANTS (*a*) (with a good degree in biological science or physiology, and preferably some research experience or qualification) and (*b*) (with a good degree in chemistry or biochemistry and preferably some research experience or qualification), to investigate the effects of chemical pollutants on marine organisms—The Secretary and Registrar, The University, Southampton (July 19).

HEAD (with high academic qualifications and considerable statistical research experience) OF THE STATISTICS SECTION, Rubber Research Institute of Malaya, Kuala Lumpur, Malaya, for duties which will include the design of field and laboratory experiments and the conduct of research in statistical matters relating to all branches of the Institute's work—The Secretary, London Advisory Committee for Rubber Research (Ceylon and Malaya), Commonwealth Institute, Imperial Institute Road, London, S.W.7 (July 31).

LECTURER (preferably with special qualifications in applied mathematics) IN MATHEMATICS at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, July 31).

RESEARCH ASSISTANT IN THE DEPARTMENT OF ZOOLOGY AND COMPARATIVE ANATOMY, to join a small group studying problems of morphogenesis—The Secretary, University College, Gower Street, London, W.C.1 (July 31).

LECTURER IN MATHEMATICAL STATISTICS at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 2).

LECTURER IN CHEMISTRY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 4).

LECTURER IN MATHEMATICS at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 20).

ASSISTANT, Grade B (graduate, preferably with some previous teaching experience), FOR MATHEMATICS, for duties which will involve work in degree and H.N.C. courses—The Clerk to the Governors, Mid-Essex Technical College and School of Art, Market Road, Chelmsford.

ASSISTANT, Grade B (man), to teach theoretical and practical physics to B.Sc. General Degree students—The Clerk to the Governors, South-West Essex Technical College, Forest Road, London, E.17.

ASSISTANT LECTURER (Grade B) IN MATHEMATICS—The Principal, Peel Park Technical College, Salford.

ASSISTANT PHYSICIST (with a first- or second-class honours degree and preferably previous experience) IN THE RADIOTHERAPY CENTRE—The Medical Superintendent, St. Luke's Hospital, Guildford.

CYCLOTRON RADIOCHEMIST (with a good degree in chemistry and preferably some experience of radiochemistry), to take charge of the chemical aspects of radioisotope production for medical research, in collaboration with existing engineering and physics teams—The Director, Medical Research Council, Radiotherapeutic Research Unit Hammersmith Hospital, Ducane Road, London, W.12.

LECTURER IN MATHEMATICS, to teach up to B.Sc. General, Part II standard; and a LECTURER (preferably with industrial or research experience) IN CHEMISTRY, with special reference to inorganic chemistry—The Clerk to the Governors, Northern Polytechnic, Holloway London, N.7.

LECTURER or ASSISTANT LECTURER (preferably with an interest in physiology and ecology) IN BOTANY at Makerere College, The University College of East Africa—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

LECTURER or SENIOR LECTURER IN METALLURGY in the Department of Mechanical Engineering—The Principal, Royal Technical College, Salford.

LECTURERS IN MATHEMATICS—Professor D. B. DeLury, Department of Mathematics, The University, Toronto.

PHYSICIST or PHYSICAL CHEMIST (with a first- or good second-class honours degree, and preferably with previous biological research experience), to work on adhesion in relation to wound dressings—The Secretary, Department of Biomechanics and Surgical Materials, Institute of Orthopædics (University of London), Royal National Orthopædic Hospital, Brockley Hill, Stanmore, Middlesex.

RESEARCH PHYSICISTS (2), to work on problems concerned with (1) X-rays and radiation dosimetry and (2) the development and application to medical research of a tritium counting apparatus—The Director, Medical Physics Unit, University of Edinburgh and South-Eastern Regional Hospital Board, 12 George Square, Edinburgh 8.

SENIOR CONTROL OFFICER (TSETSE) (aged between 30 and 45 and with at least five years experience on tsetse control work, and able to handle large gangs of labour) with the Government of the Northern Region of Nigeria—The Crown Agents, 4 Millbank, London, S.W.1, quoting Ref. M.3A/44848/TA.

SENIOR SCIENTIFIC OFFICER or SCIENTIFIC OFFICER (with a first- or second-class honours degree in physics or engineering or equivalent, and preferably a knowledge of work involving high pressure fluids, miniature precision mechanisms, strength of materials or metal physics) IN THE MECHANICAL ENGINEERING RESEARCH LABORATORY (D.S.I.R.), Plasticity Division, East Kilbride, Glasgow, to take charge of a team working on high pressure physics—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. A.226/8A.

SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS at Ministry of Supply Research and Development Establishments mainly in the southern half of England, for work in physics, electronics, electrical or mechanical engineering, applied mathematics, chemistry or metallurgy—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.182/8A.

SENIOR SCIENTIFIC OFFICERS (2) (with a first- or second-class honours degree in science or engineering and at least three years postgraduate experience) at the Headquarters of the Department of Scientific and Industrial Research, London, S.W.1, for scientific administrative duties—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.229/8A.

SENIOR SCIENTIFIC/SCIENTIFIC OFFICERS (with at least a second-class honours degree in chemistry, and for one of the posts physical chemistry or applied physics experience or qualifications would be an advantage), to join a team of chemists and chemical engineers making fundamental and applied research studies in the organic chemical field, covering investigations on preparative methods of specialized materials, and physico-chemical problems arising from production and research programmes—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. 187/34.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Proceedings of the Royal Irish Academy. Vol. 59, Section A, No. 1: A Model in General Relativity for the Instantaneous Transformation of a Massive Particle into Radiation. By J. L. Synge. Pp. 1–14. 2*s.* 6*d.* Vol. 59, Section A, No. 2: Fermi Coordinates. By L. O. Raifeartaigh. Pp. 15–24. 2*s.* Vol. 59, Section B, No. 1: The Aureole Rocks of the Leinster Granite in South Dublin, Ireland. By J. C. Brindley. Pp. 1–18. 2*s.* Vol. 59, Section B, No. 2: A Quaternary Succession at Sutton, Co. Dublin. By N. Stephens and F. M. Synge. Pp. 19–28+plates 1 and 2. 2*s.* Vol. 59, Section B, No. 3: An Ecological Study of Two Areas of Blanket Bog on the Galway-Mayo Peninsula, Ireland. By D. J. Boatman. Pp. 29–42. 1*s.* 6*d.* Vol. 59, Section B, No. 4: The Periodate Oxidation of 3-*O*-Methylglucose and 2-*O*-Methylarabinose. By P. W. D. Mitchell. Pp. 43–52. 1*s.* 6*d.* Vol. 59, Section B, No. 5: Salmon of the River Lee, 1944 and 1956. By Hazel W. Newman. Pp. 53–70. 3*s.* Vol. 59, Section B, No. 6: Deamids from the Plankton of Some Irish Loughs. By A. J. Brook. Pp. 71–02. 3*s.* (Dublin: Hodges, Figgis and Co., Ltd., 1957 and 1958.) [284

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